FINAL REPORT

BIOLOGICAL SURVEY OF THE PROPOSED KOBUK VALLEY NATIONAL MONUMENT

NATIONAL PARK SERVICE
UNITED STATES DEPARTMENT OF THE INTERIOR

Final Report

BIOLOGICAL SURVEY OF THE PROPOSED KOBUK VALLEY NATIONAL MONUMENT

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Edited by
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United States Department of the Interior

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INTRODUCTION

An exploratory biological survey of the area proposed under the Alaska Native Claims settlement Act, paragraph 17d (2) as the Kobuk Valley National Monument (Fig. 1) was conducted by the Alaska Cooperative Park Studies Unit, University of Alaska, Fairbanks under contract CX-9000-3-0136, CO #3 with the National Park Service. The project was initiated in May, 1974. Field work was accomplished during September 15-20, 1973 (preliminary visit under an earlier contract); July and August, 1974; and during March 11-15, 1975. An itinerary of the field program is listed in Appendix A.

The objectives of the survey were:

(a) to conduct field studies of the flora and vegetation plus literature-based analyses of productivity rates and short-to-long-term community dynamics of the vegetation of the proposal area with some emphasis placed on those plant species or communities that may be involved in man's subsistence activities,
and

(b) to conduct field studies of the mammals, gather some information dealing with the fish resource of the proposal area, make literature-based analyses of productivity rates and short-to-long-term dynamics of the fauna of the proposal area, with some emphasis placed upon those species that may be involved in man's subsistence activities.

Our report is presented in three parts: Part I, which describes and analyzes the physical factors that affect the biological systems of the Kobuk River drainage; Part II, which describes the flora and vegetation of the proposed Kobuk Valley National Monument (KVNM); and Part III, which examines the vertebrate populations, utilizing habitats within the proposed KVNM.

The proposed KVNM encompasses an area of 750,529 ha that lies within the boreal forest-tundra ecotonal region of northwestern Alaska, consequently, species usually associated with or characteristic of both the tundra biome and the boreal forest or taiga biome can be expected to occur within the boundaries of the proposed monument. Within this area, elevations range from 15 m to 1451 m. The area is topographically diverse and experiences considerable variation in climate, factors that, along with repeated glaciation and glacial retreat, have influenced the development of the vegetative cover and the animals that live within the Kobuk valley. The proposed KVNM together with the proposed Noatak National Arctic Range, which lies to the north of and is contiguous with the KVNM, contain a diversity of animal and plant communities representative of the taiga and tundra of northwestern Alaska.

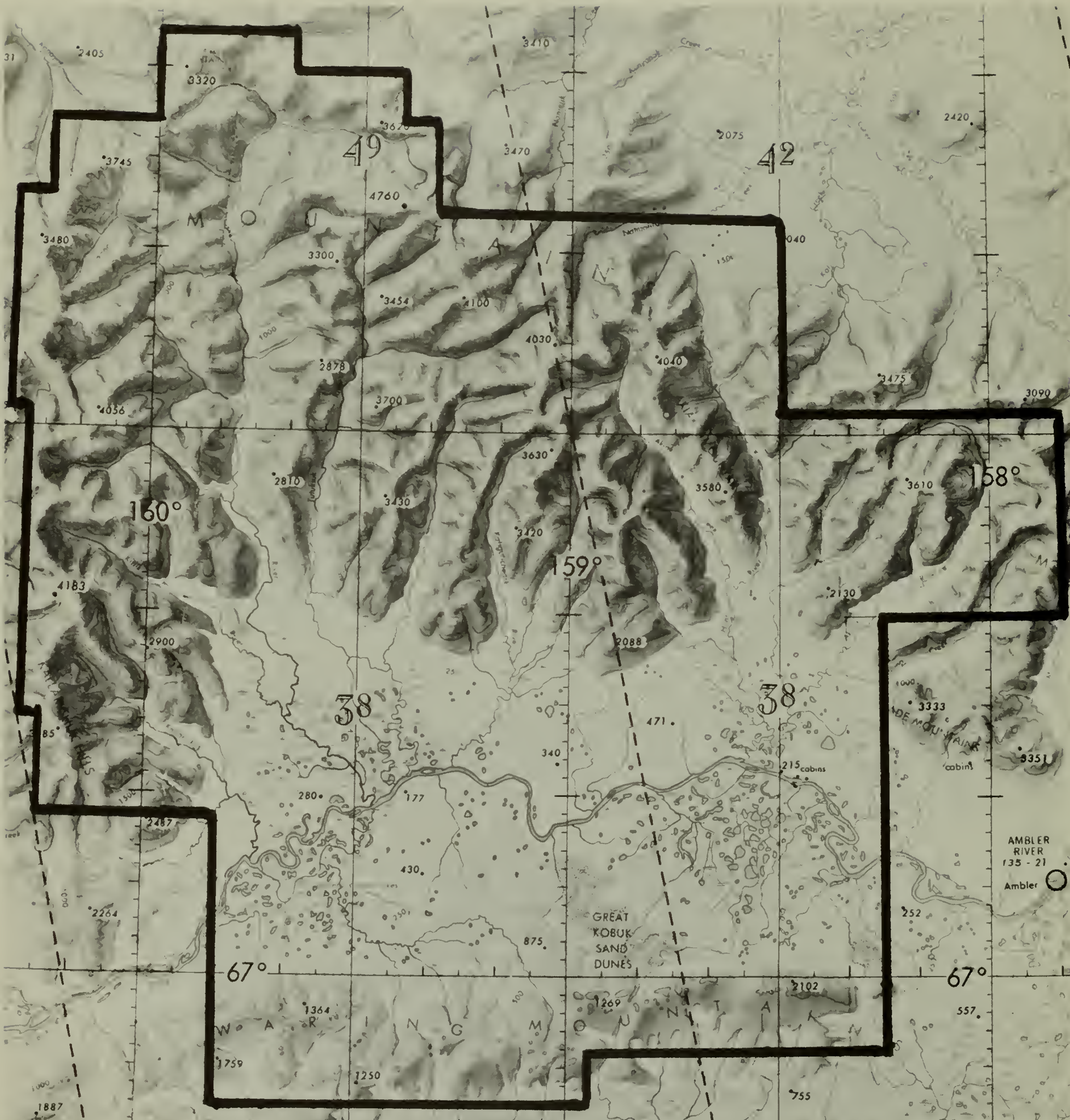

Figure 1. General relief and approximate boundaries of the proposed Kobuk Valley National Monument in northwestern Alaska. Approximate scale: 1 cm = 58 km.

ACKNOWLEDGMENTS

Dr. John Dennis, now of the Office of Chief Scientist, National Park Service, Washington, D.C., must be credited with recognizing the need for and pressing for the undertaking of a biological study of the proposed Kobuk Valley National Monument area as a complement to a NPS study of the residents of the valley and their utilization of the resources. Dr. Frederick Dean, Leader of the Cooperative Park Studies Unit at the University of Alaska, Fairbanks, has assisted the project in many ways. The people who live along the Kobuk River deserve special recognition for their assistance and for making our temporary stay in the area such a pleasant experience. In Ambler, we wish to thank Peter and Barbara McManus and Dan and Joyce Denslo for opening their homes to us and providing us with a place to stay and Mark Cleveland, for providing us a place to store some of our equipment and supplies. All of the above, together with Keith and Anore Jones and many other residents of Ambler, gave us insight into the environment of the region through hours of interesting discussion. Howard and Erna Kantner generously allowed us to use their house near the mouth of the Hunt River on our trip down the Kobuk and in Kiana, Ray and Amelia Blastervoeld and Tommy and Ella Sheldon provided us with food, shelter, information, and companionship during our stays in that village.

We also wish to thank Irv Tailleur, Field Leader of the joint Federal-State geological survey party camped near Kiana, for his cooperation in the use of the party's helicopter to get us and our gear to the upper Salmon River. Finally, we need to thank Dr. John Dennis and other National Park Service personnel, especially in the Anchorage office, for their patience in waiting for this final report of the Kobuk Valley Biological Survey.

PART I

PHYSIOGRAPHY, CLIMATE, AND FIRE: A Description and Analysis of Physical Factors Affecting the Biological Systems of the Kobuk River Drainage

by

Herbert R. Melchior

The primary objective of our biological survey was to examine through field study and literature review, the major biological components of the ecosystems within the proposed Kobuk Valley National Monument (KVNM). However, since the biological components of the ecosystem are affected by and interact with various physical factors and features of the environment, this section consisting of a description and analysis of major physiographic features, climate, and fire, is presented here as an aid to understanding and interpreting the biological aspects of the ecosystems within the valley.

PHYSIOGRAPHY

The study area encompasses the middle portion of the westward flowing Kobuk River between the villages of Ambler on the east and Kiana on the west (Fig. 1). It extends from the crest of the Baird Mountains on the north, where the peaks range in height from 1060-1450 m, to and including the Waring Mountains on the south, where the peaks range in height from 381-640 m. Five major river systems enter the Kobuk from the north draining the south slopes of the Baird Mountains through long, deep and gradually sloped valleys. The water from these rivers is cold, fast-moving, and clear, except after major rain storms. Water flowing north down the gentle slopes of the Waring Mountains and across the valley floor into the Kobuk is warm, slow-moving, and dark-appearing. Although surficial deposits both north and south of the Kobuk River include flood plain alluvium and terrace and fan alluvium, the area north of the river contains many areas characterized by glacial drift, which is essentially absent south of the river, while the area south of the river contains large regions of both active and stabilized dune sand, which is all but absent from the north side of the river (Fernald, 1964). The active dune areas include the Great Kobuk Sand Dunes, a small area on the south side of the Kobuk River opposite the mouth of the Hunt River, and a portion of the Little Kobuk Sand Dunes. Thus, the Kobuk River represents a dividing line between two rather different substrate and aquatic environments which lie within the forest-tundra ecotone that extends along the south slopes of the Brooks Range.

Several fairly distinct physiographic or landscape types can be

recognized within the study area. The Kobuk River runs through a valley bottom that varies from 29-40 km in width. This valley can be subdivided into two physiographic subtypes: one, the modern flood plain of the river, which varies from 3-5 km in width and includes such physical features as slip-off slopes, steep cut banks, gravel bars, oxbow lakes and thaw lakes in various stages of formation; and another, the area back of the flood plain, which consists of terraces that stand up to 30-60 m above the river and include such features as thaw lakes and dune fields (Fernald, 1964; Smith, 1913). One of the largest dune fields in the Kobuk River valley lies in the south central portion of the study area between Niaktuvik Creek on the east and Kavet Creek on the west. The active portion of this field, the Great Kobuk Sand Dunes, covers approximately 65 km^2 or about one third of the area of the total field. On the east, this field rises from the flood plains and low terraces of Ahnewetut and Niaktuvik Creeks, and on the west, southwest and south it is banked up along Kavet Creek, the Waring Moutains, and the upper course of Niaktuvik Creek. Ahnewetut Creek has maintained its course through the dune field; but Kavet Creek has been forced westward by the advancing sand, and Niaktuvik Creek has been confined to the foothills of the Waring Mountains in its upper course. A 30 m escarpment outlines the northern border of this field with the Kobuk River flood plain (Fernald, 1964). Although portions of the dune fields in the central Kobuk valley remain active today, the most intense dune activity probably occurred during and following the four glaciations that have occurred in the Brooks Range within the last 40,000 years (Fernald, 1964; Hamilton, 1973, 1974).

The lower slopes and foothill region of the Waring Mountains consist of gently rounded hills and slopes whereas the lower slopes and foothills of the Baird Mountains consist of steeper slopes, rock outcrops, and, where the south flowing rivers have cut through ridges, cliff faces. These cliffs often represent unusual habitat for plant species (see Racine, Part II, this report).

The Waring Mountains which bound the Kobuk valley on the south, have gently curving surfaces and reach a maximum elevation of 640 m. The low elevation of the Waring Mountains probably accounts for the fact that the north flowing streams from these mountains are sluggish and slow moving throughout most of their courses.

The Baird Mountains, which bound the Kobuk valley on the north and serve to divide the Noatak River and Kobuk River drainages, display a rugged topography and reach a maximum elevation of 1450 m. Steep-walled circue valleys and lakes occur at high elevations in the Baird Mountains. Streams heading in these mountains and flowing south are swift.

These two mountain masses separated by the Kobuk valley in combination with a complex glacial-interglacial climatic and geologic history have created a diversity of geomorphological types within the boundaries of the proposed KVNM.

CLIMATE

As in other regions of the world, weather and climate control the types of processes responsible for morphological changes in the Kobuk valley and determine the rate and duration of effectiveness of both biological and morphological processes in the region. Traditional concepts of seasons, as viewed in the contiguous 48 states, must be modified when applied to northern regions (Walker, 1973).

Continuous, long-term weather records for locations within the Kobuk River valley are lacking. However, records of a few years length exist for Noorvik on the delta and for Shungnak and Kobuk on the upper river. The Bureau of Land Management contracted with Ella Sheldon of Kiana in 1974 to collect weather data from May 1 to August 26, 1974 in connection with their fire control program. All of these records, in addition to other observations, were examined for both short-term and long-term patterns.

GEOGRAPHIC PATTERNS

Mean and extreme monthly temperatures during 1974 for the village of Kobuk and the city of Kotzebue, located on the northern tip of the Baldwin Peninsula and 258 km west of Kobuk, are shown in Figure 1a. Although the monthly means are similar between these two stations, Kobuk experiences far more extreme temperatures than does Kotzebue. Kobuk lies 64 km east of the eastern boundary and Kotzebue lies 122 km west of the western boundary of the proposed KVNM; consequently, one can question whether or not either station reflects low elevation temperatures within the proposed KVNM. Although year around temperature data from a station near the boundary of KVNM are not available, temperatures for May through August 1974 were recorded in Kiana, located 26 km west of the western boundary of the proposed KVNM. The mean and extreme temperatures from Kiana are compared with Kotzebue in Figure 1b; those from Kobuk are compared with Kotzebue in Figure 1c. From this comparison, it is clear that during the summer of 1974, the ambient temperatures along the river at Kobuk, east of the proposed KVNM, and at Kiana, west of the proposed KVNM, were more similar to each other than the temperatures at either station were to Kotzebue.

Figure 2 shows monthly precipitation recorded at Kobuk, at Kiana and at Kotzebue for 1974. Kobuk received more than twice the annual precipitation recorded at Kotzebue (386 mm compared to 174 mm). From May through August, Kobuk recorded 302 mm, Kiana recorded 220 mm and Kotzebue recorded 98 mm. Thus the summer precipitation pattern at Kiana was more similar to the pattern at Kobuk than it was to the pattern at Kotzebue even though Kiana is much closer to Kotzebue (93 km) than it is to Kobuk (159 km).

Long term trends in summer (May through August) precipitation are

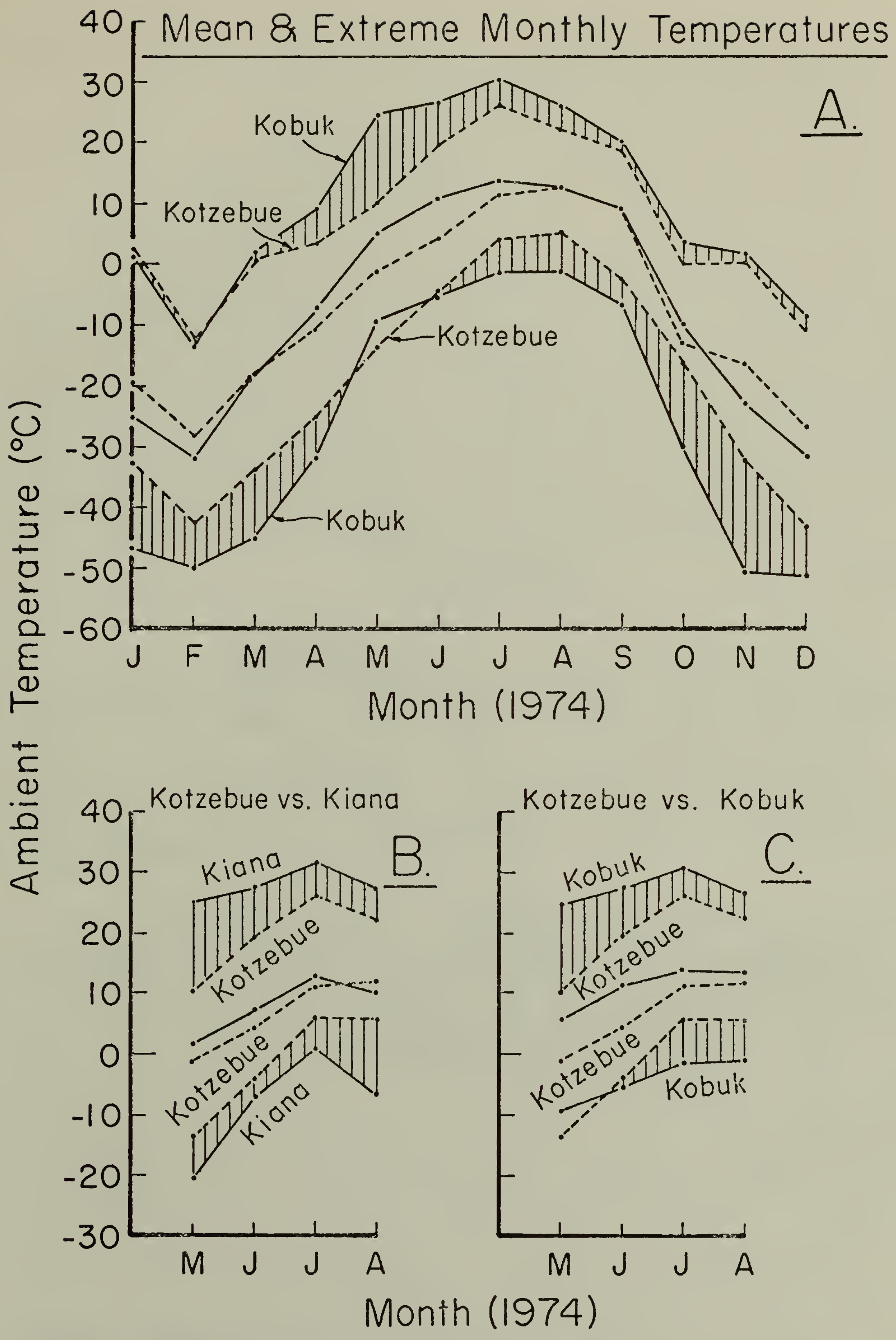

Figure 1. Mean and extreme monthly temperatures.
a. Kotzebue versus Kobuk, Alaska, 1974.
b. Kotzebue versus Kiana, May through August, 1974.
c. Kotzebue versus Kobuk, May through August, 1974.

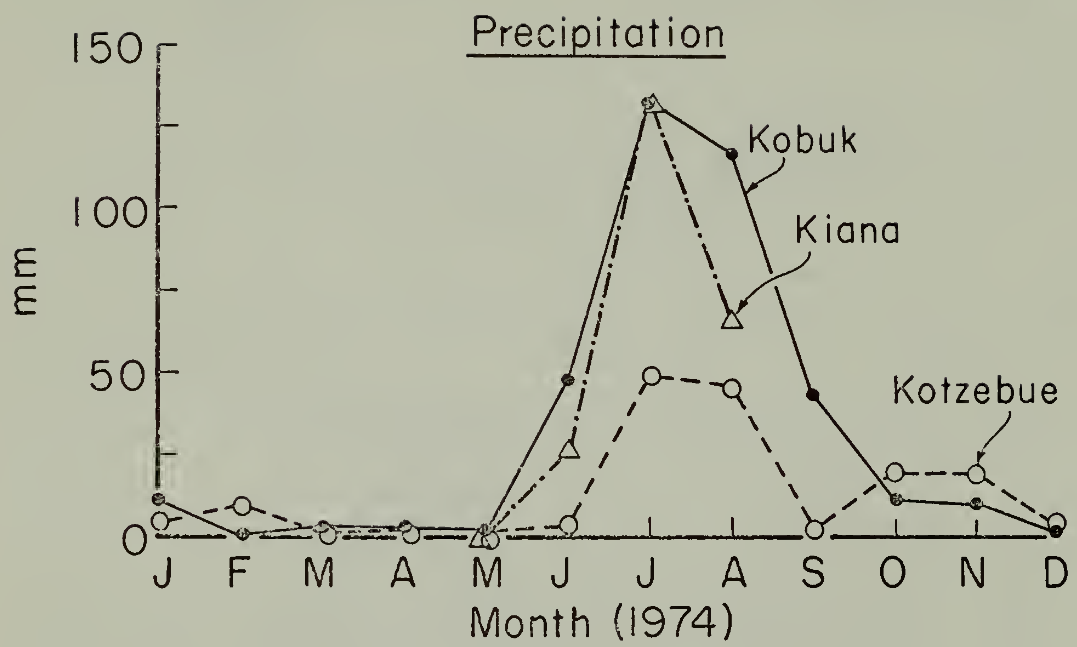

Figure 2. Monthly precipitation at Kotzebue, Kiana, and Kobuk, Alaska, 1974.

shown in Figure 3. Examination of this graph reveals these features:

(1) high variability in total summer rainfall between years;

(2) high year to year variability in the amount of rain falling in a given month, i.e. high seasonal variability;

(3) in the 21 years of record, the maximum monthly rainfall occurred in either July or August;

(4) six of the 21 summers (1923, 1925, 1947, 1950, 1968, and 1971) were quite dry; and

(5) an analysis of variance of the total summer precipitation and total annual precipitation for Noorvik, Shungnak, and Kobuk revealed there was no significant differences between these three stations (F= .97, 2/18 df and F=.25, 2/16 df, respectively), however, this finding may be due to the small size of our sample, especially from Noorvik. One should expect Noorvik, which is located only 32 km east of Hotham Inlet and 67 km east of Kotzebue, to have a total annual precipitation more similar to that at Kotzebue than to that of the up-river stations. If Noorvik has, on the average, a total annual precipitation that is significantly less than the up-river stations, then a longer record than is now available will be required to detect the difference.

Summer

At high latitudes summer, defined as the period between March 21 and September 22, does not have very much meaning with respect to the period of plant growth or with respect to the period of winter-free conditions as they relate to the activities of animals and humans. Although all four seasons, spring, summer, fall, and winter, exist at the latitude of the Kobuk River, the climatic conditions usually associated with spring and fall seasons, as experienced at mid latitudes, cover a very short time.

From a practical standpoint, especially with regard to conditions that affect animal activity and movement in the valley, summer can be defined as the period when water surfaces are in the unfrozen state. Perhaps the best available index of this condition is the period between spring break-up and fall freeze-up of the river. Table 1 lists break-up and freeze-up dates of the Kobuk River at the villages of Kobuk, Shungnak, Kiana, and Noorvik. The mean date for break-up ranges from May 20th at the uppermost village of Kobuk to May 31st at the village of Noorvik located on the Kobuk River delta. Keith Jones, who has lived on the Kobuk River in the vicinity of Ambler since 1963, said that his observations agree with the trend shown by the dates in Table 1 that break-up occurs earlier up-river than it does down-river. The mean date for break-up at Kiana, May 18th, seems out of line with this trend. This early date is an anomaly and is due to the influence of the Squirrel River entering the Kobuk at Kiana causing the ice to break up in front of the village before doing so either above or below the village (Keith Jones, pers. comm.).

The mean date for freeze-up of the Kobuk River ranges from October

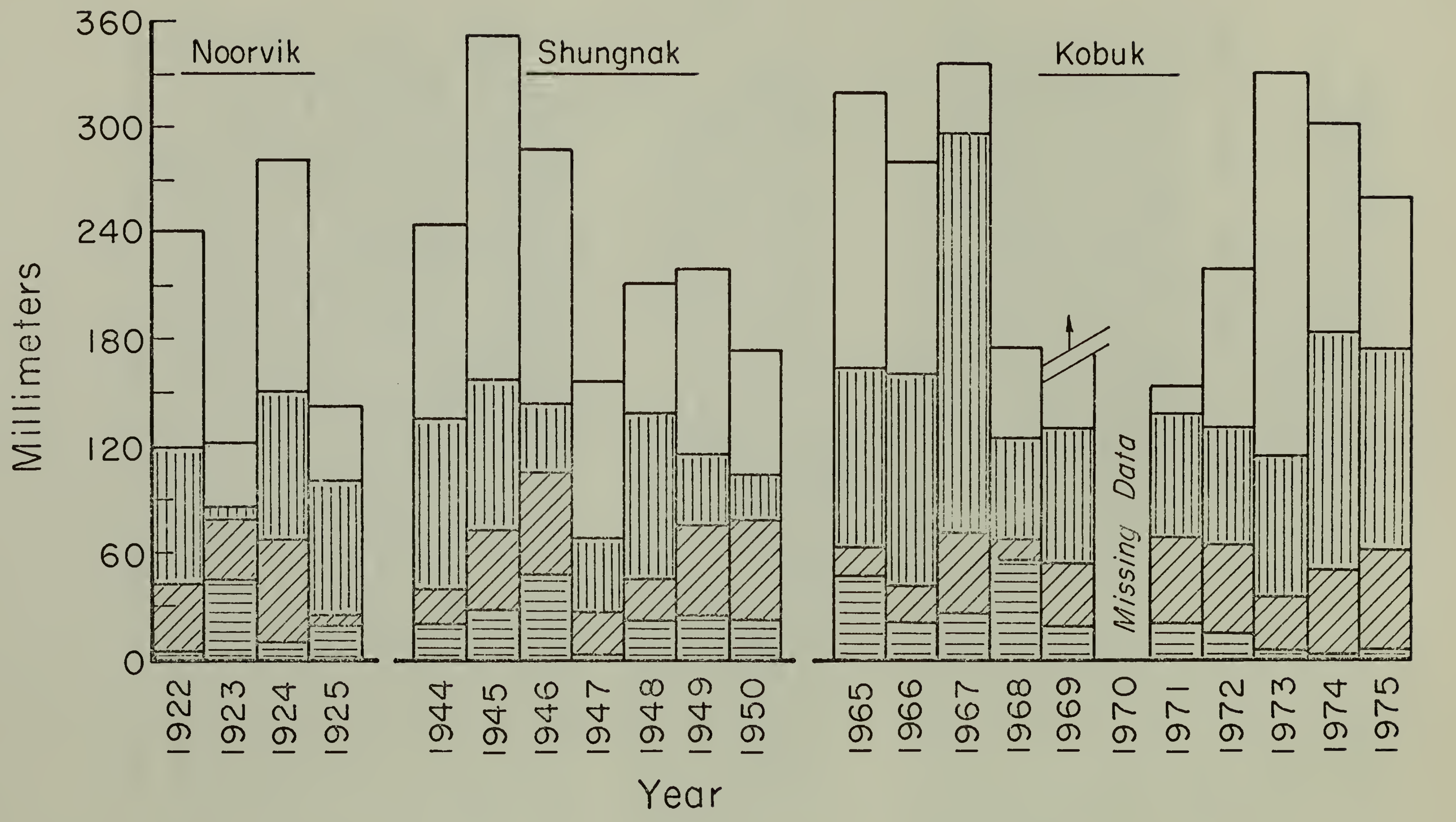

Figure 3. Summer precipitation at three Kobuk River stations, Noorvik, Shungnak, and Kobuk for years in which records are available. Horizontal = May; left downward diagonal = June; vertical = July; open = August.

Table 1. Kobuk River break-up and freeze-up dates at Kobuk, Shungnak, Kiana and Noorvik.

Year	Break-up				Freeze-up				Source
	Kobuk	Shungnak	Kiana	Noorvik	Kobuk	Shungnak	Kiana	Noorvik	
1885						18 Oct			Smith and Eakin, 1910
1886		6 Jun							Smith and Eakin, 1910
1898						15 Oct			Smith and Eakin, 1910
1899		24 May							Smith and Eakin, 1910
1912						22 Oct			Foote, 1966
1915		17 May							Foote, 1966
1916		22 May		1 Jun		17 Oct			Foote, 1966; USDA, 1916
1917				1 Jun					USDA, 1917
1918				2 Jun?				3 Oct	USDA, 1918
1919		14 May		25 May		7 Oct			Foote, 1966; USDA, 1919
1920		4 Jun				3 Oct		3 Oct	Foote, 1966; USDA, 1920
1921		18 May		30 May		9 Oct		2 Oct	Foote, 1966; USDA, 1921
1922		27 May		11 Jun		18 Oct		25 Oct	Foote, 1966; USDA, 1922
1923		18 May		25 May		4 Nov		18 Oct	Foote, 1966; USDA, 1923
1924		20 May		1 Jun		10 Oct		8 Oct	Foote, 1966; USDA, 1924
1925		12 May		18 May		1 Nov		15 Oct	Foote, 1966; USDA, 1925
1926		15 May		1 Jun		31 Oct		15 Oct	Foote, 1966; USDA, 1926
1927		28 May				11 Oct			Foote, 1966; USDA, 1927

Table 1. Continued.

Year	Break-up				Freeze-up				Source
	Kobuk	Shungnak	Kiana	Noorvik	Kobuk	Shungnak	Kiana	Noorvik	
1928		14 May				7 Oct			Foote, 1966; USDA, 1928
1929		14 May				11 Oct			Foote, 1966; USDA, 1929
1931		19 May				11 Oct			Foote, 1966; USDA, 1931
1932		22 May				15 Oct			Foote, 1966; USDA, 1932
1933		26 May							Foote, 1966; USDA, 1933
1934		21 May							Foote, 1966; USDA, 1934
1935		29 May				18 Oct			Foote, 1966; USDA, 1935
1937					27 Oct				USDA, 1937
1938	16 May				2 Nov		4 Nov		USDA, 1938
1939	22 May		29 May		9 Oct		10 Oct		USDA, 1939
1940			7 May			25 Oct	17 Oct		USDA, 1940
1941	12 May	12 May	14 May		14 Oct	14 Oct	14 Oct		USDC, 1941
1942		18 May	19 May		14 Oct	11 Oct	11 Oct		USDC, 1942
1943	11 May		17 May	26 May	28 Oct		23 Oct	20 Oct	USDC, 1943
1944	24 May	25 May	22 May	27 May	25 Oct	25 Oct		23 Oct	USDC, 1944
1945	29 May	29 May		3 Jun	12 Oct			9 Oct	USDC, 1945
1946	18 May	18 May		28 May	28 Oct			28 Oct	USDC, 1946
1947		20 May							USDC, 1947

Table 1. Continued.

	Break-up				Freeze-up				
Year	Kobuk	Shungnak	Kiana	Noorvik	Kobuk	Shungnak	Kiana	Noorvik	Source
1948	24 May	24 May		31 May		15 Oct		26 Sep	USDC, 1948
1949	25 May	24 May		31 May	14 Oct	13 Oct		9 Oct	USDC, 1949
1950	16 May	16 May			9 Oct*				USDC, 1950
Mean Date	20 May	22 May	18 May	31 May	21 Oct	17 Oct	19 Oct	13 Oct	
Earliest Date	11 May	12 May	7 May	18 May	12 Oct**	3 Oct	11 Oct	26 Sep	
Latest Date	29 May	6 Jun	29 May	11 Jun	2 Nov	4 Nov	4 Nov	28 Oct	

*Records list two dates, 9 October (first ice) and 26 October (ice safe for man).

**Excepting 9 October 1950 date which may not indicate freeze-up as determined in other years.

13th at Noorvik to October 21st at Kobuk. This trend for freeze-up to occur earlier at down river stations than at up-river stations is significant (Wilcoxon Signed-Rank Test, $P<.01$). Again, Kiana represents an anomoly.

The ice-free period for the Kobuk River has ranged from as little as 121 days at Shungnak in 1920 to as long as 170 days at Kobuk in 1938 and again in 1943 (Table 2). The mean ice-free period is 154 days up-river at Kobuk and 135 days down-river at Noorvik which represents 42 per cent and 37 per cent respectively of the year.

Summer temperatures and precipitation, as recorded at Kobuk from 1970 through 1974, are shown in Figure 4. Although mean monthly temperatures vary from one year to another, the variation is small compared to the variation in precipitation. July and August, 1973 were particularly wet months. Total July and August rainfall in 1973 was greater than for these two months in any other year of record on the Kobuk River (Fig. 3). But even in years of lower summer precipitation, individual summer storms can have a pronounced affect on the valley, particularly with respect to runoff and stream flow. An example from the summer of 1974, when our party was in the field, will serve to show what an impressive change can occur within a few hours.

Very little precipitation fell in the Kobuk valley during May, June and the early part of July in 1974 (79.0 mm at Kiana and 44.71 mm at Kobuk through July 25th). On July 26th a storm began moving in from the south. Rainfall was light to moderate on the 26th and 27th but became heavy on the 28th and 29th (Table 3). Both Kiana and Kobuk are located by the river and therefore are low elevation stations. Rainfall at higher elevations was probably greater than at these stations. Our group was camped on the upper Salmon River and preparing to float down-river when the storm moved in on us. On the evening of the 27th, the river was shallow and running clear even though we had had two days of intermittent light rain. On the morning of the 28th the Salmon was swollen and carrying a lot of silt and debris. The river had risen an estimated 45 to 60 cm within 12 hours in its upper reaches. As we discovered a few days later, the Kobuk River had risen considerably more than this amount and it stayed high for at least a week. Based upon the driftwood level along the banks of the river, the high water mark of the Kobuk River at the mouth of the Salmon resulting from this storm exceeded the high water level reached during spring break-up. Apparently a similar storm event occurred on about the same dates in 1973 (Roger A. Bolstad, Bureau of Land Management, Fairbanks, Alaska, pers. comm.).

Primary production at northern latitudes is greatly influenced by temperature. Giddings (1941) reported a strong positive correlation between growth rate, based on tree-ring records, and mean June temperatures in the Kobuk valley and interior Alaska. More recently, soil temperatures have been recognized as an important factor in the growth of both native and exotic plant species in Alaska (e.g. see

Table 2. Length of ice-free period, year and length of shortest ice-free period, year and length of longest ice-free period, Kobuk River. (Based on data from Table 1.)

	Kobuk		Shungnak		Kiana		Noorvik	
	Year	Days	Year	Days	Year	Days	Year	Days
Mean		154		148		154		135
Shortest	1945	136	1920	121	1939	134	1918	123
Longest	1938	170	1925	173	1940	163	1925	150
	1943	170						
Mean per cent of year ice-free		42		41		42		37

Table 3. Precipitation at Kiana and Kobuk during the storm of July 26-29th.

Station (Source)	July: 26	27	28	29	Storm Total
	Precipitation (mm)				
Kiana (BLM)	12.70	11.18	43.69	8.64	76.21
Kobuk (USDC)	.76	1.52	50.80	40.64	93.72

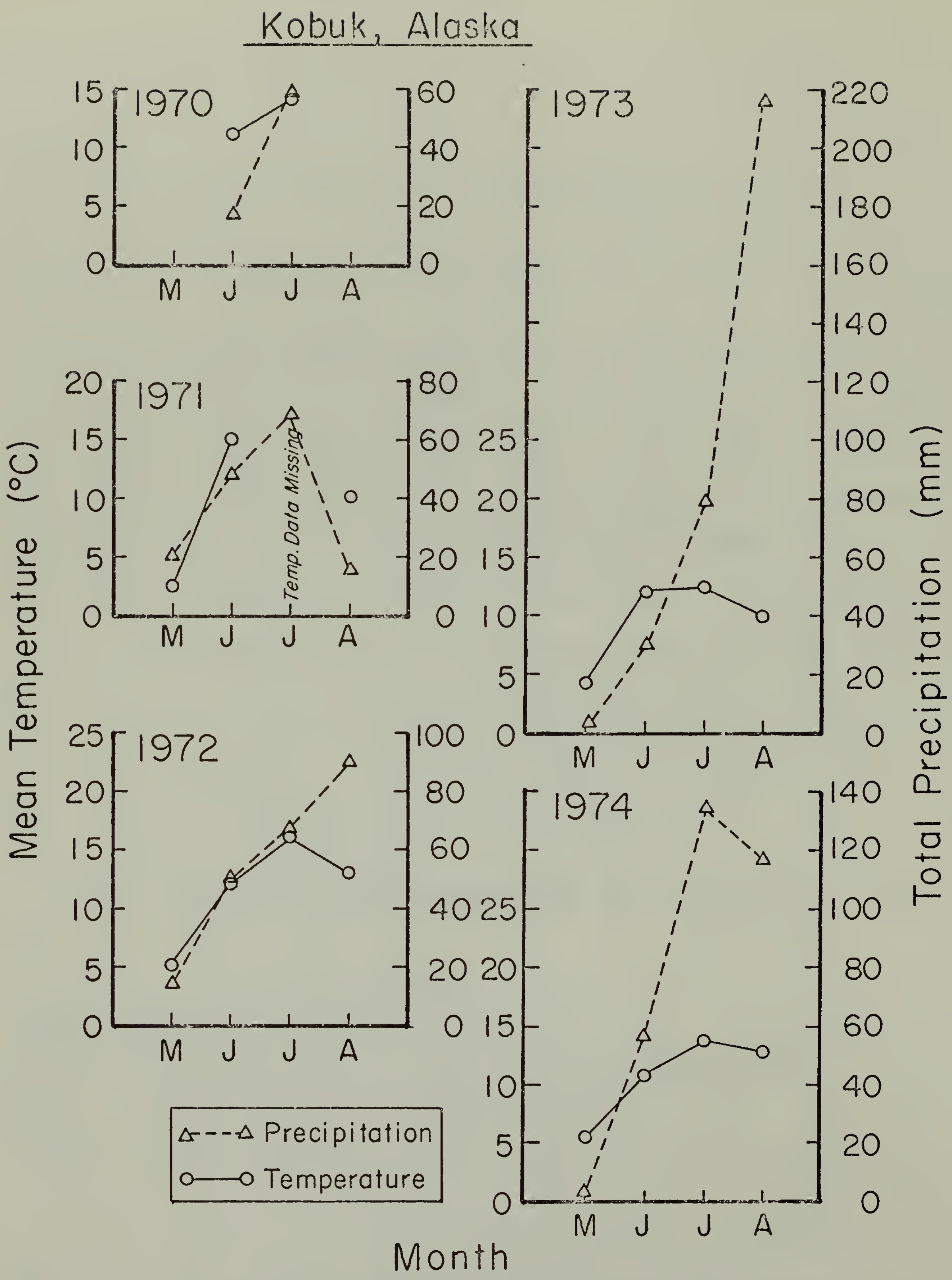

Figure 4. Monthly mean temperature and monthly total precipitation in summer during 1970 through 1974 at Kobuk, Alaska.

McCown, 1973). Unfortunately, there are no known soil temperature data from the Kobuk valley. The number of frost-free days (an estimate of growing season) is, perhaps, the most useful climatic parameter that is available for indicating the potential for annual plant growth in the Kobuk valley (Table 4). As in the case of the other climatic data, the records for any one station are short and the periods of record for different stations do not overlap in time; consequently, one must be cautious about placing too much confidence in apparent trends. The data in Table 4, however, suggest that up-river stations have a shorter growing season than down-river stations, since the mean length of frost-free period at Kobuk is 25 days less and at Shungnak 10 days less than at Noorvik.

But these data also suggest that the mean frost-free period has been diminishing over the period that records have been kept. The mean number of frost-free days at Kobuk during the 1965 to 1975 period was 54 days while the mean number of frost-free days at Shungnak, only 11 km west of Kobuk, for the period 1944 to 1950 was 69 days. Thus, although these two stations are geographically close to each other, they show a greater difference in length of frost-free period (15 days) than the difference between Shungnak and Noorvik (10 days), two stations that are located 170 km from each other. Another way of looking at the data in Table 4 is that the difference in mean number of frost-free days between Noovik and Shungnak over a period of approximately 25 years (early twenties to mid forties) and a distance of 170 km is much less than the difference in mean number of frost-free days between Shungnak and Kobuk over a more recent period of 25 years (mid forties to late sixties) and a distance of only 11 km. One way of explaining these differences is to hypothesize a fairly stable climate during the first 25 year period and a cooling trend during the second 25 year period.

In summer the prevailing winds are mainly from the south at an average speed of 11 km per hour in the vicinity of Kiana (Table 5). However, wind speed and direction varies with location, time of day, and topography, therefore the data presented in Table 5 should only be viewed as providing a general indication of summer wind characteristics.

Winter

At the latitude of the Kobuk River, the period between freeze-up and break-up represents about 60 per cent of the year (Table 2) and each year during the last ten years, the ground has been covered with 2.5 cm or more of snow for an average of 62 per cent of the year (Table 6). Total snowfall at Noorvik in the 1920's and at Kobuk from the mid sixties to the mid seventies has averaged about 1400 mm and has ranged from a low of 521 mm in 1968-69 to a high of 2365 mm in 1966-67 at Kobuk. There is no significant difference in mean annual snowfall between Noorvik and Kobuk (Table 6). This result is surprising in view of the considerable distance between these two stations, their position relative to the sea, their difference in topographic setting, and the

Table 4. Dates between and number of frost-free days at Kobuk, Shungnak, and Noorvik on the Kobuk River (USDA, 1918-1925; USDC, 1944-1965; USDC, 1966-1970; USDC, 1970-1975).

Year	Number of Days Between 0°C	Latest and Earliest Date with 0°C or Colder (Frost-free Period)
NOORVIK		
1918	60	26 June to 25 August
1920	80	7 June to 26 August
1921	79	15 June to 2 September
1922	79	11 June to 29 August
1923	99	10 June to 17 September
1924	58	16 June to 13 August
1925	98	28 May to 3 September
	mean = 79	mean = 12 June to 30 August
SHUNGNAK		
1944	64	5 June to 8 August
1945	56	12 June to 7 August
1946	73	25 May to 6 August
1947	80	26 May to 14 August
1948	74	7 June to 20 August
1949	45	30 June to 14 August
1950	92	2 June to 2 September
	mean = 69	mean = 6 June to 15 August
KOBUK		
1965	49	1 June to 20 July
1966	63	31 May to 2 August
1967	65	25 June to 13 August
1968	77	8 June to 24 August
1969	49	5 June to 24 July
1972	83	7 June to 29 August
1973	34	9 June to 13 July
1974	24	13 June to 7 July
1975	44	15 June to 29 July
	mean = 54	mean = 9 June to 1 August

Table 5. Wind direction and wind speed at Kiana, Alaska, for May, June, July, and August, 1974. Based on data collected by Ella S. Sheldon for Bureau of Land Management, Fairbanks District, Fairbanks, Alaska.

Month	Mean Direction	Mean Speed (km/hr)	Maximum Speed (km/hr)	Number Readings With Wind Blowing	Number Readings With No Wind Blowing	% Readings When Calm
May	SSE	10.8	20.9	43*	21*	33
June	S	11.4	30.0	50	10	17
July	SSE	10.6	35.4	42	20	32
August**	ESE	12.3	24.1	37	15	29

*Two extra readings were made this month, thus the sum of these two numbers is greater than 2 x 31 days in the month.

**Readings were taken for only the first 26 days of this month.

Table 6. Winter snowfall at Noorvik and Kobuk on the Kobuk River (USDA, 1919-1927; USDC, 1964-1975).

Noorvik		Kobuk			
				2.5 cm or More on the Ground	
Winter	Total Snowfall (mm)	Winter	Total Snowfall (mm)	Number of Days	% of Year
1919-20	>1684.02	1964-65	>1117.60	>145	
1920-21	>1767.84	1965-66	>1054.10	243	67
1921-22	1897.38	1966-67	2364.74	210	58
1922-23	2303.78	1967-68	2286.00	220	60
1923-24	1384.30	1968-69	520.70	220	60
1924-25	1150.62	1969-70	>1158.24	>183	
1925-26	835.66	1970-71	>1358.90	229	63
1926-27	762.00	1971-72	>449.58	>121	
	mean = 1388.96*	1972-73	1524.00	239	65
		1973-74	685.80	226	62
		1974-75	1041.40	≥208	
			mean = 1403.77*	mean = 227*	mean = 62

*Mean based upon years of complete record. Years marked by a greater than sign, indicating an incomplete record for the winter, were excluded from the calculations. There is no significant difference between mean total winter snowfall at Noorvik and Kobuk ($t = .036$, $df = n_1 + n_2 - 2 = 10$).

difference in period of record between the two stations.

Total snowfall is an insufficient measure with respect to the importance of snow conditions in relation to the activities of animals and men in winter. Depth and density or hardness are far more useful measures for interpreting the biological significance of snow cover. Our field survey studied primarily summer biological conditions, however, we recognize that weather conditions during the long period of winter bears importantly on the biological system; therefore the Kobuk valley was visited on March 13-15, 1975 to obtain some impression of the winter conditions.

The snow cover of several habitats was sampled for snow depth and hardness using a Rammsonde penetrometer (Bull, 1956; Benson, 1962) which measures the resistence of snow to the penetration of a cone. The resistence represents the work done by the Rammsonde in penetrating a vertical distance through the snow pack and this is equal to the loss of potential energy of the Rammsonde and weights. Therefore, it is possible to calculate the energy (Joules) required to penetrate to a specific depth by multiplying the Ram Hardness Number by the depth penetrated (cm) and the constant 0.098. Thus, a stratum within a snow profile can be represented by a Ram Hardness Number or the energy required to penetrate the stratum and the entire profile can be represented by the total energy required to pass through all of the strata. A fuller discussion of this methodology and its application to snow cover studies will be found in Bull (1956), Benson (1962, 1969), Coady (1974), and others.

Maximum snow depths and total energy required to penetrate to maximum depths by Rammsonde for eight locations within the proposed KVNM are given in Table 7. Ram Hardness profiles for six different habitats at eight locations are shown in Figure 5. The tussock tundra profile (Fig. 5a) from the north side of the Kobuk valley resembles, in general features, some of the profiles taken by Benson (1969, Fig. 16) at Lake Noluck on the north slope of the Brooks Range, a site that is within the Alaskan tundra, while the profiles from the willow scrub and lichen woodland habitats (Figs. 5b, c, d, e) are more characteristic of interior Alaska snow profiles (Benson, 1967). The tussock tundra snowpack is moderately hard in the upper portion of the profile, just firm enough to support humans and animals. The willow scrub and lichen woodland habitats generally consist of low density snow throughout the profile. Over the course of the winter, a depth hoar develops from the soil-snow interface upward as the result of an upward migration of water vapor. This drying action, caused by a strong temperature gradient within the snow profile, can result in the top 4-5 cm of soil becoming dry dust as the end of winter approaches (Benson, 1967). The Ram profile from the Hunt River Sand Dunes (Fig. 5g) resembles the upper portion of a profile of a snow drift on the Meade River (Benson, 1969, Fig. 21). The snow cover over the Hunt River Dunes was not only deep but firmly packed. It would support a man easily so that one's boot hardly left a track after passage. Similarly, caribou tracks, although

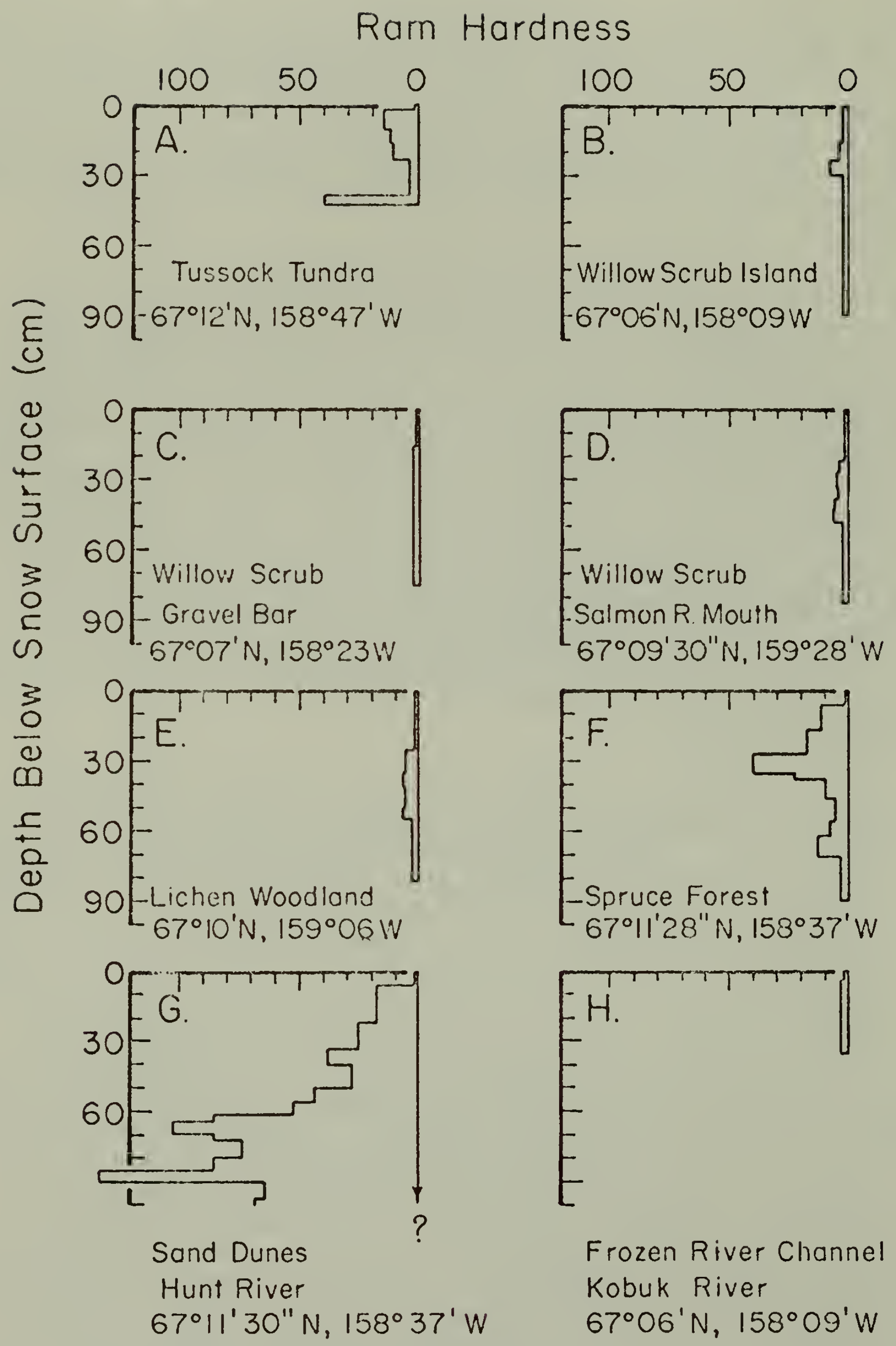

Figure 5. Rammsonde snow hardness profiles for eight locations in the proposed Kobuk Valley National Monument.

quite visible, were essentially surface marks having penetrated the snow surface very little. The profile from within the spruce forest habitat just south of the southern edge of the Hunt River Dunes (Fig. 5f) appears to have some of the characteristics of snow drift in the upper half of the profile, but the characteristics of a wind-free interior site (soft, low density snow with depth hoar development) in the lower half of the profile. This could be an indication that the early winter snows are not accompanied by strong winds in this area but that later in the winter, storm winds drift the snow. The Hunt River Sand Dunes profile might also show this pattern but we lacked the extension tube necessary to sample the snow to the base of the profile at the dunes sampling site. The Ram profile in Figure 5h was taken through the snow cover lying over the frozen river channel next to the willow scrub covered island (Fig. 5b). The snow over the channel was soft and only a third as deep as the snow cover in among the nearby willows, which suggests that wind passing through the area may have been removing snow from over the river channel but not from among the willows nearby.

Although the total snow sampling effort was preliminary in nature, the data gathered are sufficient to allow me to suggest that within the proposed Kobuk Valley National Monument there exists at least three basic types of snow cover.

Type I . . . In this type the snow depth approximates the seasonal accumulation of snow at the time of measurement. The caracteristics are low density and low Ram Hardness number throughout the profile. This type occurs where the vegetation consists of medium to tall shrubs, woodlands, or forests. Although I did not take temperatures, I would predict that generally there would be a strong temperature gradient within the profile of this type with cold temperatures (at or near ambient) at the top of the profile grading to moderately warm temperatures near the base of the profile as usually occurs in the valleys and flatlands of interior Alaska (Benson, 1967; Trabant, 1970). Examples include Figures 5b, c, d, e, and in part, f).

Type II . . . In this type, the snow depth approximates the height of the tallest vegetation regardless of total seasonal snowfall (except at the very beginning of winter). Snow depth in this type is controlled mainly by an interaction between wind and vegetation. The characteristics are moderate densities and Ram Hardness numbers in the upper portion of the profile and low density and low Ram numbers in the lower portion of the profile. A temperature gradient should exist but temperatures at the base of a profile should be colder than in Type I snow cover. The gradient should be sufficient to create depth hoar at the base of the profile, however. This type is common within the tundra regions of Alaska. Snow cover of this type would generally have profiles similar to the one shown in Figure 5a.

Type III . . . In this type, wind is a primary factor in its formation and the snow depth generally exceeds the seasonal accumulation of snow as measured at a wind-free site. In this type, snow accumulates

Table 7. Maximum snow depth and total energy required to penetrate to maximum snow depth by Rammsonde for selected habitats in the Kobuk River valley, Alaska on March 14, 1975.

Habitat and Location															
Frozen River Channel 67°06'N/ 158°09'W		Tussock Tundra 67°12'N/ 158°47'W		Willow Scrub Island 67°06'N/ 158°09'W		Willow Scrub Gravel Bar 67°07'N/ 158°23'W		Willow Scrub Salmon River 67°09'30"N 159°28'W		Lichen Woodland 67°10'N 159°06'W		Spruce Forest 67°11'28"N 158°37'W		Sand Dunes Hunt River 67°11'30"N 158°37'W	
cm	J	cm	J	cm	J	cm	J	cm	J	cm	J	cm	J	cm	J
35	9.8*	45	58.8	89	19.4	76	--	78	16.1	96	37.9	100	127.2	100	442.0
36	9.0	50	45.1	87	27.8	71	--	73	15.0	90	37.0	98	86.7	100	480.2*
30	20.6	49	53.7	86	30.6	72	10.1	83	21.0*	97	30.3	90	100.4*	100	509.6
30	11.8	39	54.7	86	22.7	71	10.3	86	24.4	87	22.4				
36	10.0	48	38.8	90	23.5*	58	10.3	>76	>49.0	78	21.7				
		40	51.9			81	15.2			81	24.2*				
		43	58.4			75	14.1*								
		49	41.9			77	16.0								
		42	49.4*			78	16.2								
		45	32.3			79	15.5								
						72	12.8								
						75	13.5								
						73	13.6								
						80	15.1								
MEANS 33	12.2	45	48.5	88	24.8	74	13.6	80	19.1	88	28.9	96	104.8	**	477.3

*Ram profile plotted in Figure 5.

**Maximum depth sampled was 1 m.

J = joules

cm = centimeter

forming drifts because of the interaction of wind and local topographic features. The characteristics of this type are high density and high Ram Hardness numbers throughout the profile. The temperature gradient would probably be less steep than in Type I snow for the same depth. Figure 5g represents an example of this type.

In addition to or separate from these profile types of snow cover, there are many types of snow surface conditions that develop which can affect the activities and movements of animals and men in winter (e.g. see Pruitt, 1970, 1975). Examples include the formation of zastrugi (wind sculptured forms), snow dunes, and water saturation of the snow surface during spring melt. These features of the snow cover, although not measured by this survey, are important aspects of the winter climate.

Henshaw (1964, 1968), Pruitt (1959, 1970), and others have discussed the ecological importance of various aspects of snow cover.

Few data exist on wind speed and direction in winter for the Kobuk valley. John Henshaw made 31 observations of wind direction and speed in and near the Kobuk drainage between November 15, 1961 and March 15, 1962 in connection with a study of environmental factors governing caribou winter activity.[1] Wind speed ranged from calm to 24.6 m/sec (55 mph) and in 15 of the 31 observations the winds blew from the NE, the apparent prevailing direction for winter winds in the area. As in summer, wind speed and direction varies with location, time of day, and topography. Winter storms, accompanied by strong winds, generally do not last for more than 4 days (Henshaw, 1964, 1968) but they can be very severe while they last.

FIRE

Fire is recognized as an important factor affecting subarctic ecosystems (e.g. Slaughter, Barney and Hansen, 1971; Viereck, 1973) but most studies of the effects of fire have been conducted in interior Alaska, especially in the vicinity of Fairbanks. However, fire is also an important factor along the forest-tundra ecotone and out into the tundra biome, especially in northwestern Alaska (Melchior, in press). In Alaska the Bureau of Land Management has the responsibility for fire control (direct responsibility on federal lands, under contract with the state on state lands). Figure 6 which shows the location of lightning caused fires in the Kobuk River region for the years 1965 to 1969 and 1970 to 1974 was derived from computer printout maps obtained from the Fire Control division of the Fairbanks District BLM.

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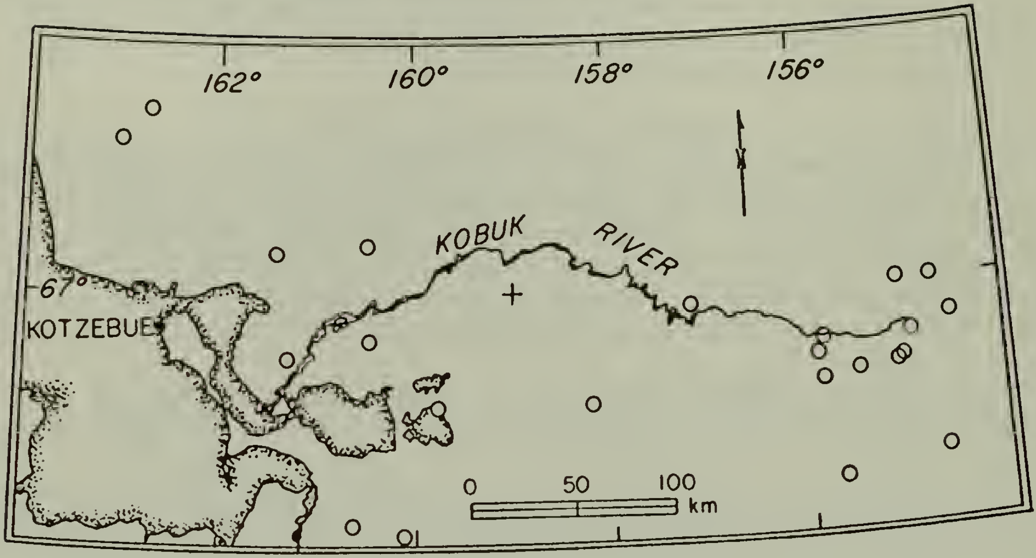
[1] Henshaw, J. 1963(?). Environmental factors governing caribou winter activity. Unpubl. Job Completion Rept., Proj. No. W-6-R-4, Work Plan C, Job No. 5. 61 typed pp. Copy on file at Coop. Wildlife Res. Unit, Univ. Alaska, Fairbanks.

Fires Recorded 1965-69



Fires Recorded 1970-74

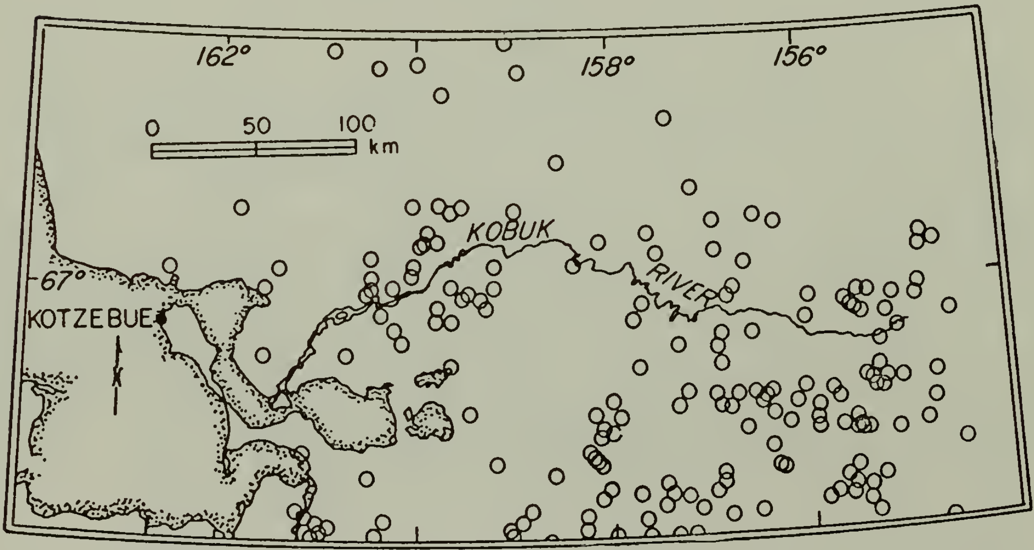


Figure 6. Top. Locations of lightning fires, 1965-69. Bottom. Location of lightning fires, 1970-74. From data supplied by Division of Fire Control, Bureau of Land Management, Fairbanks District.

In northern Alaska experience shows that with ERTS imagery it is possible to distinguish burned areas from unburned areas for a period of four to five years after a burn. After five years, enough vegetation develops so that one must inspect suspected burn areas from the ground or by low altitude flying to confirm one's suspicions that an area was burned.

In order to determine how much of the area of the proposed Kobuk Valley National Monument has been burned during the last five years, we examined Bureau of Land Management Fire Reports and a 30 June 1974 ERTS image, No. 1707-21391 (Fig. 7). The fire number, year of the fire, location, and two estimates of the size of the fires, one from the fire reports and one based on planimetry of the 1:1,000,000 scale ERTS image, are given in Table 8. Fire report estimates, which are usually made in the field by the fire boss, are probably much less accurate than careful measurement by planimeter of fire scars as they appear on an ERTS image. This is particularly true when the area of the fire as reported in a fire report represents an estimate made when the fire was first observed. If not corrected when the fire is out, the estimate reported can be considerably less than the actual area burned. The 1972 fire named Slam might be a case in point. Using a 1973 ERTS image of the proposed KVNM magnified to a scale of 1:250,000, Racine (this report) determined by planimetry that from 1970 through 1973, 224 square km had burned. Two major fires occurred within the proposed KVNM during 1974 which totaled 109 square km based on my planimetry of a 1:1,000,000 scale ERTS image (Table 8). Thus, during the last five years, 333 square km has burned. This represents 4.4 per cent of the total proposed KVNM; 8.0 per cent of the area that is covered by vegetation other than alpine meadows, mountain barrens and mobile sand dunes; or 11.7 per cent of the valley floor (Fig. 7). The latter was arbitrarily delineated to exclude the foothills and mountains within the proposed KVNM. Using these criteria, the valley floor represents 32 per cent of the total area.

Racine (Part II, this report) mapped a unit he named Willow, Alder, and Young Spruce Scrub, which are the major species present in successional communities found in areas that had burned more than four to five years ago. If we add the area represented by this type (152 square km) to the area of recent burns, then the area affected by fire during recent historical times represents 6.4 per cent of the total proposed KVNM; 11.6 per cent of the area covered by vegetation other than alpine meadows, barrens, and mobile sand; and 18.0 per cent of the valley floor. Based upon this analysis, lightning fires represent an important factor in the environment of the proposed KVNM.

DISCUSSION AND CONCLUSIONS

The Kobuk River flows westward for approximately 450 km (Orth, 1967) along the south side of the western end of the Brooks Range to Hotham Inlet. Within the boundaries of the proposed KVNM, the river serves to divide two major phsyiographic divisions, the Baird Mountains and the

Table 8. Year, location, and estimated size of lightning fires within the proposed Kobuk Valley National Monument in 1970 through 1974.

Fire Number	Year	Location	BLM Estimate of Size (ha)	Planimetered Size on ERTS image 1707-21391 (1974) (ha)
9980	1970	Hunt River	2	No estimate made
9613	1970	Kitlik River	324	No estimate made
9721	1971	Tunatuk Creek	7285	8000
8861	1972	Kallarichuk River	931	2000
8726 8727 8728 8743	1972	South of Nigeruk (VABM)	4140	6520
8899 8916	1972	Slam (VABM)	10	5200
8603	1973	Salmon River	9	Fire not visible at designated location
	1974	Kallarichuk River		5700
	1974	Tutuksuk River		5200

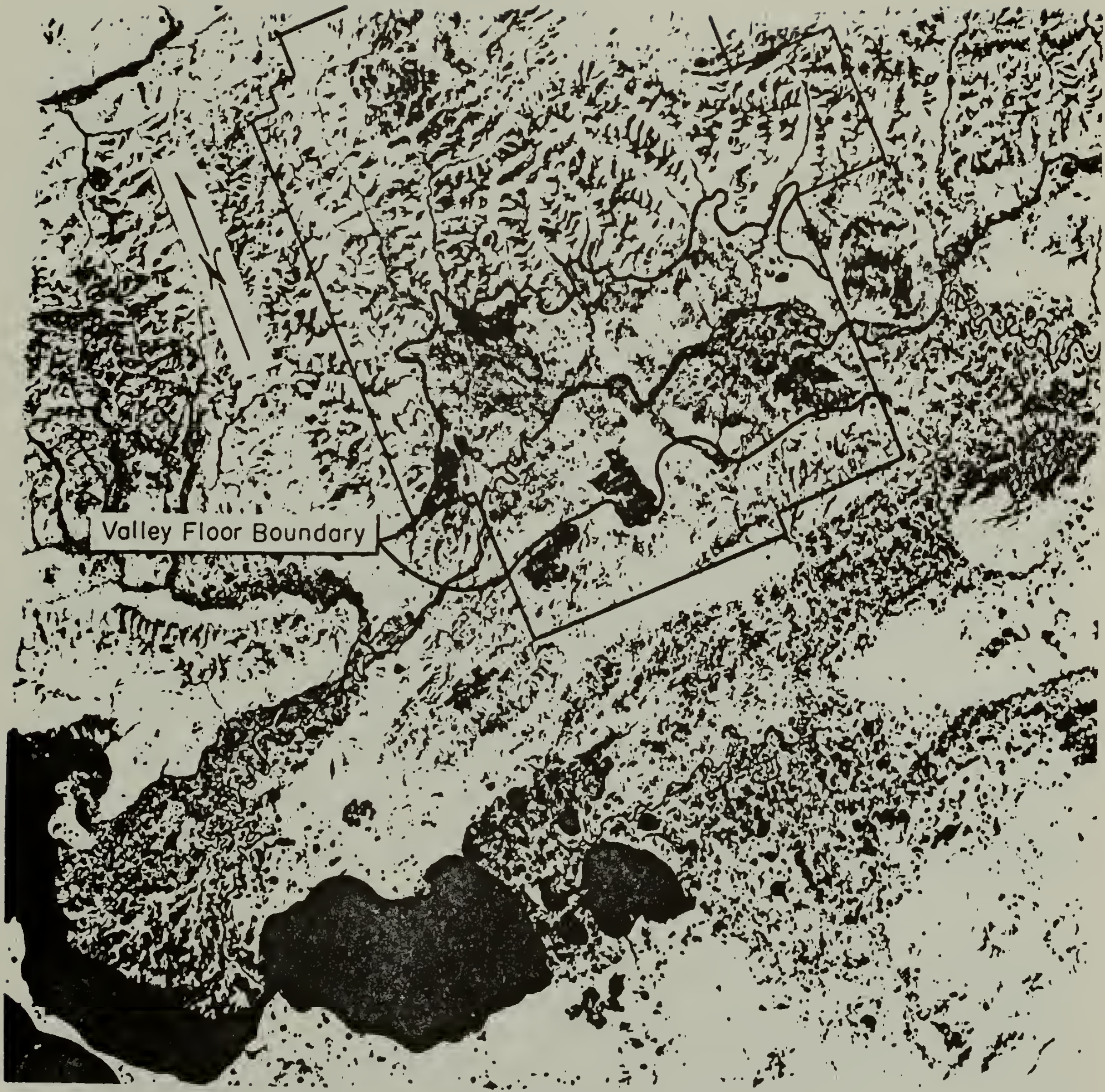


Figure 7. Earth Resources Technology Satellite Image (No. 1707-21391) of the Kobuk River region taken on 30 June 1974 showing terrain features and fire scars (irregularly-shaped black areas). Wandering, narrow black line crossing the proposed KVNM boundaries marks the boundary of the valley floor.

Kobuk-Selawik Lowland (Wahrhaftig, 1965). The Baird Mountains are part of the Rocky Mountain System, the Kobuk-Selawik Lowland is part of the Intermontane Plateaus (ibid). Although the major physiographic features of these two divisions can be traced back to the Tertiary and perhaps earlier; the present landforms result primarily from erosional and depositional processes that have been strongly influenced by, and in some instances, are unique to regions of cold climate.

Paleoecological studies in northwestern Alaska indicate that throughout the Quaternary the region was basically under the influence of a varying but cold, frost or periglacial climate, that is, one that has an annual mean temperature below 0°C (Bird, 1967; Hopkins, 1972; Matthews, 1974; Wahrhaftig, 1965). During the Pleistocene, the region passed through alternating glacial and interglacial periods, consequently, evidence of past mountain glaciation and periglacial features can be found in the region.

As a consequence of the long period of time that the region has experienced a cold, frost climate, the region is underlain by permafrost; that is, the ground below a depth of a few cm to several m is frozen the year around. The active layer, the zone between the upper surface of the permafrost and the ground surface, undergoes alternate periods of freezing and thawing. The depth of the active layer at the time of maximum thaw (usually in August) depends to a large extent upon the insulating qualities of the vegetation covering the ground surface. Very wet or saturated soils covered with vegetation that has a large moss component, especially *Sphagnum* spp., may only thaw to a depth of 6 to 10 cm whereas thinly vegetated well-drained, coarse soils may thaw to a depth of several meters. Interactions between features of a cold climate, vegetative cover, substrate characteristics, and topography affect erosional and depositional processes to produce a great variety of mass movement and periglacial patterned ground features. Many of these features are found in the proposed KVNM and include solifluction features on slopes, polygonal features such as ice wedge polygons in the Kobuk valley, and sorted and unsorted patterns in the uplands. Ice movement down the rivers during spring break-up is an important factor in shaping the landscape along water courses.

It is beyond the scope of this report to analyze in detail the geomorphic processes that have in the past and are today affecting the landscape of the proposed KVNM; however, it is important to recognize that these processes continue today to shape existing landscape units and affect the biological systems associated with them. For more detailed discussions of the effects of frost climates on geomorphic processes at northern latitudes, the reader is referred to works by Bird (1967), Wahrhaftig (1965), Washburn (1973), and authors cited by them.

The climatic data presented and analyzed here leads me to the conclusion that most of the Kobuk River valley, including the area of the proposed KVNM, has a continental climate that exhibits very little influence of the marine climate that exists so close by to the west.

The data shown in Figures 1, 2, and 3 clearly show that mean monthly temperatures and annual precipitation at stations in or near the delta of the river (Noorvik and Kiana) are not much different from those at up-river stations (Shungnak and Kobuk). Similarly, there was no evidence of a significant difference in total winter snowfall between down-river and up-river stations (Table 6). Dan Denslo, owner and operator of Ambler Air Service, who makes frequent trips up and down the Kobuk River as well as flights to Kotzebue, told me that he frequently encounters abrupt changes in weather along the eastern shoreline of the Baldwin Peninsula, just east of Kotzebue, and near the Kiana Hills, in the vicinity of Kiana. Usually these changes are marked by changes in cloud conditions. These observations together with evidence from the weather records referred to earlier, suggest that there is a rather narrow zone along the west coast within which weather that produces a maritime climate gives way to weather that produces a continental climate. At times this zone is breached by storms from the west, mostly in summer, but the general conditions that prevail in the Kobuk valley are those of a continental type climate. The rareity of coastal sand dune plant species on the Great Kobuk Sand Dunes (Racine, Part II, this report) provides additional evidence that climatic conditions suitable for maritime species are lacking.

The year to year and month to month variation in summer precipitation within the Kobuk drainage (Fig. 3) produces large effects with respect to surface wetness and runoff. In periods of relatively high rainfall, surfaces are very wet and soggy and streams and rivers appear to be in a continuous flood stage. This occurs because the underlying permafrost prevents deep percolation and cool temperatures inhibit evaporation; consequently, water from precipitation is confined to a shallow surface zone which becomes saturated rather easily. Conversely, periods of low precipitation leave the tundra and forest surfaces dry and the streams and rivers low. Even a single rain storm, as happened in the summer of 1974, can produce a dramatic change from a condition of low water to one of flood stage. The biological consequences of exceptionally dry or exceptionally wet summers are not known for the Kobuk region. Indeed, even in interior Alaska where river systems have been studied in greater detail than has the Kobuk, the biological consequences of year to year fluctuations are not known. That important effects probably occur, especially in lotic systems, can be inferred from our general knowledge that marked changes in the rate of flow of streams and rivers effects changes in many biologically important chemical and physical parameters of aquatic systems such as turbidity, sediment load, bottom configuration, and nutrient composition For example, increased turbidity decreases visibility for fish, such as grayling, that depend on vision to find food. Even a single rain storm which causes increased turbidity may cause a decrease in feeding activity (Vascotto, 1970). It is conceivable that a summer of high precipitation could, by keeping streams in a nearly continuous state of high turbidity, reduce summer feeding activity and thereby reduce growth of visual feeders during summers of high precipitation and runoff.

Not only is the variability in total summer precipitation high from one year to the next but also it is high from year to year for a given month (Fig. 3). Thus, during the month of July, for example, the precipitation ranged from as little as 7.9 mm in 1923 to as high as 226.1 mm in 1967. In other words, the existing data indicate that there are no predictable patterns to the variation in precipitation. Since most aquatic organisms resident in Alaska's northern waters, both invertebrate and vertebrate, reproduce, grow, and carry on their major activities during the relatively short northern summer, the unpredictable nature of major biological, chemical, and physical conditions of lotic environments during the important summer period must be of some consequence to these aquatic organisms and to other organisms affected by variation in lotic systems. As pointed out by Watt (1973) and others, unstable physical environments usually lead to low diversity ecosystems inhabited by unstable populations of organisms. Only further studies, however, will reveal whether or not the variability in seasonal and yearly precipitation has significant effects on specific organisms inhabiting the Kobuk River drainage.

The finding that freeze-up tends to occur earlier at down-river stations than at up-river stations (Table 1) came as a surprise and is inconsistent with one's expectations. I do not see any logical climatological explanation for this trend. It is possible that the explanation lies in the fact that since different observers were recording the event at each village they may have used different criteria for judging freeze-up. Normally, one would expect freeze-up to occur at about the same time throughout the length of the river or to start somewhat earlier at the up-river stations than at the down-river ones due to the higher elevation of the latter stations and their interior (more continental) location. Break-up occurring at the up-river stations earlier than at the down-river stations is consistent with observations of break-up on rivers throughout Alaska and is expected because of snow melt and spring rains initiating the process in the tributaries of the drainage basin.

Examination of Table 4, which shows the latest and earliest date of 0°C or colder, reveals an average difference of only 10 days in the length of the frost-free period between Noorvik in the 1920's and Shungnak in the 1940's, while the difference in mean length of frost-free period between Shungnak in the 1940's and Kobuk in the 1960's/1970's is 15 days. Since Shungnak and Kobuk are only 11 km apart and usually have rather similar weather, this difference (decline) in the length of the frost-free period could be an indication of a cooling trend in the climate of the upper Kobuk River (and perhaps more broadly, northwestern Alaska). An increase in the number of glaciers that are surging in the Alaska Range and evidence that temperature has been cooling at a rate of 0.16°C per year for the past 10 years (as recorded at a high altitude glacier weather station) (Larry Mayo, U.S.G.S., Fairbanks, pers. comm.), lends support to the idea that our Alaskan climate is cooling. Hamilton's (1965) analysis of Alaskan temperature trends, which showed a decline in annual mean temperature since the

maximum centered around 1941, is also consistent with the evidence presented in this report and the glacier studies just cited. Additional data should be examined, however, to test this hypothesis.

Winter snow conditions within the Kobuk drainage basin are highly variable. According to Pruitt (1960, 1970), the Kobuk Eskimos have at least 14 words in their language for snow and various snow conditions. At least half of these terms relate to surface conditions of the snow cover.

Based upon my limited quantitative sampling, three very basic profile types can be recognized, a low density type characteristic of low elevation interior Alaska, a type with moderate to high density near the upper surface and low density near the base of the profile that occurred in a tussock tundra area subject to frequent winds, and a snow drift type. Wind is an important factor in the formation of the second and third types. The configuration of the surface of these two types can vary from a smooth surface to a highly irregular one that is so uneven that it impedes movement of animals, machines, and men even though it is firm enough to support their weight. The first type, characterized by low density throughout the profile, can also impede movement of men and large animals, if deep enough, but serves as an important insulative blanket for small mammals active under the snow (Pruitt, 1960, 1970). Since the ground is covered with at least a couple of centimeters of snow for 60 per cent of the year or more (Table 6), conditions of the snow cover are of considerable importance to the resident biota. A great deal of additional sampling is needed in order to adequately describe the range of snow conditions and the geographic distribution of various types within the Kobuk River drainage. Year to year variation is sufficient to require more than one winter of sampling in order to begin to relate snow conditions and distribution to biological processes within various habitats.

Comparison of Figure 6a with 6b shows a striking difference between the number of fires during the 1965 to 1969 period versus the number of fires during the 1970 to 1974 period. The increase in the frequency of fires during the more recent five year period could be due to changes in those climatic conditions which are conducive to lightning-caused fires or attributable to better surveillance and reporting of fires (Barney, 1971). Examination of Figure 3 for May during the 1965 to 1969 and 1971 to 1974 period at Kobuk, however, shows that the earlier period received more precipitation in May than the later period and a statistical analysis confirms this difference ($t = 2.43$, 7 df, .025). Furthermore, total winter snowfall (Table 6) during the 1965 to 1969 period averaged more ($\bar{x} = 1468$ mm) than during the 1970 to 1974 period ($\bar{x} = 1035$ mm), consequently, there was less input of surface moisture during spring break-up in the latter period than in the earlier one. Since nearly all fires in the Kobuk region are caused by lightning, low winter snowfall, and low precipitation during May allows the surface to dry out during and following spring break-up more completely than in years with higher snowfall and higher May precipitation. Dry springs, therefore, cause a

build-up of dry fuel that increases the probability of fire by lightning. Thus, although better detection of fires may contribute to the higher frequency of fires recorded during the second five year period, there is climatological evidence that conditions for fire were better during that period than during the earlier period.

In summary, eight points should be emphasized:

(1) Within the boundaries of the proposed KVNM, there is considerable physiographic diversity;

(2) The north side of the Kobuk River drainage basin is distinctly different from the south side of the basin and this distinction is reflected in characteristics of the aquatic systems of the two sides;

(3) The sporadic nature of the weather records within the Kobuk River drainage, both in space and time, emphasize the need for caution in the interpretation of trends and patterns of weather. Nevertheless, the existing data indicate that the climate within the Kobuk River drainage is basically a continental type;

(4) Since the Kobuk region is now and has been for several thousand years under the influence of a periglacial climate, it contains many landscape features that are characteristic of and result from the geomorphic processes that occur under such a climate;

(5) The available weather records show that there is substantial variability in all climatic parameters. This variability probably has important biological consequences but little is known about the effects of this variability on organisms inhabiting the Kobuk region;

(6) Based upon a decline in the length of the frost-free period, the Kobuk valley appears to have undergone a trend toward cooler summers during the past 25-30 years;

(7) It is important to remember that the available weather records all come from low elevation stations adjacent to the Kobuk River, consequently, the data presented are not representative of many parts of the drainage basin nor of the variability existing within the basin during any particular period of time; and

(8) Throughout recorded history, and especially during the last five years, fire has been an important ecological factor in shaping the existing ecosystems, particularly at lower elevations where it has impacted an estimated 18 per cent of the valley floor.

ACKNOWLEDGMENTS

Many individuals assisted me in gathering the information presented and analyzed here but several deserve special recognition. Ty Sindon of

the Bureau of Land Management Fire Control office in Fairbanks made available weather records from Kiana and obtained for me copies of the maps showing the locations of fires recorded by B.L.M. during the past ten years. Keith Jones of Ambler, Alaska gave freely of his personal knowledge of winter conditions on the Kobuk and Dan Denslo, also of Ambler, provided excellent air service with his PA-12 on skiis that allowed me to sample snow conditions wherever I pleased and added his personal observations of weather conditions along the coast to my analysis of local weather records. Finally, I would like to thank "Lefty" Schallock of Fairbanks for listening and responding to my questions about the effects of variable climatic conditions on northern aquatic ecosystems.

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PART II

FLORA AND VEGETATION

by

Charles H. Racine

In northwestern Alaska, the subarctic Boreal forest reaches its limits on the south slopes of the Baird Mountains which divide the valleys of the west-flowing Noatak and Kobuk Rivers. While the Noatak valley is largely covered with tundra, the Kobuk valley is forested and representative of the broad forest-tundra ecotone in Alaska. Both the Kobuk and Noatak valleys are significant because of their close proximity to the eastern end of the Bering Land Bridge which provided a route for the migration of plants and animals between interior and coastal Alaska and Asia. The flora and vegetation of the Kobuk valley has intrinsic scientific value in relation to treeline phenomena, extensive sand dune fields, Beringian migrations and utilization by valley residents.

This report describes the flora and vegetation of the middle section of the Kobuk valley. A map of the major vegetation types is included.

PREVIOUS STUDIES OF THE FLORA AND VEGETATION

Although there have been several important botanical studies in northwest Alaska, few detailed studies of the Kobuk flora and vegetation exist. Early explorations of the Kobuk by McLenegan (1889), Stoney (1900), and Mendenhall (1902) provide very superficial descriptions of the vegetation and flora. More recently, Jordal (1951) studied the floristics and phytogeography of the southern slopes of the Brooks Range.

Sigafoos (1958) visited several sites within the Kobuk valley during the course of his studies of the relationships between vegetation and frozen ground. He characterized the study area as a region of discontinuous permafrost.

During the summer of 1963, Shetler[1] made vascular plant collections

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[1]Shetler, S. G. 1964. A progress report on the botanical work. Pp. 114-130 in F. C. Dean, ed. Biological Investigation of the Baird and Schwatka Mountains, Brooks Range, Alaska 1963. Wildlife and Fisheries Program, Univ. Alaska, Fairbanks, Ak. Mimeo. (On file in Wildlife and Fisheries Library and with Conservation Foundation, Washington, D.C.)

in the Baird and Schwatka Mountains region between the Kobuk and Noatak Rivers. He collected around Redstone Lake and Walker Lake in the Kobuk drainage; both sites lie east of our study area (cf. Dean and Chesemore, 1974). Shetler felt that the flora and vegetation of these Kobuk sites were more mesophytic than interior regions to the east and similar to coastal regions to the west. He cited as evidence, the presence of a diverse fern flora and such species as Asplenium viride, Heracleum lanatum, and Potentilla villosa. The vegetation (habitats) at Redstone and Walker Lakes is described by Dean and Chesemore (1974). They emphasize the presence of two gradients as "tree line" and the edge of the taiga are approached: a decrease in both the diversity and the abundance of taiga species. They also comment on the nature of barriers to the migration of boreal species from the Kobuk to the Noatak valleys across the Baird and Schwatka Mountains. They describe several habitat life forms or vegetation types at Redstone Lake. Forest covers 40% of the area. Half of this forest is closed spruce forest and the other half is divided into closed mixed forest and open spruce forest. Tall shrub and dry tundra each occupy 10% of the total area. Tussock-heath tundra occurs in the valley bottoms and covers 30% of the area. Sedge-grass marsh, standing waters, flowing waters and bluffs, sides, and outcrops each make up less than 5% of the total area surveyed. Tree line occurs at an elevation of about 600 m, 300 m higher than in our study area only 32 km to the west. At Walker Lake treeline rises to elevations between 600 and 900 meters.

Prior to this study vegetation maps covering the Kobuk valley were prepared at scales of 1:250,000, 1:2,500,000 and 1:5,000,000. A map by Sigafoos (1958) at a scale of 1:2,500,000, shows only three vegetation types in our study area: a) interior spruce and birch forest in the valley lowlands with extensions up the Salmon River; b) two patches of herbaceous tundra in the lowlands north of the Kobuk River; and c) rock deserts, sand plains and bare rock covering much of the Baird and Waring Mountains. Spetzman (1963) mapped nine major vegetation types onto a 1:2,500,000 scale Alaska vegetation map and also used the same nine units on a series of 1:250,000 U.S. Geological Survey topographic maps. His effort represents the only other vegetation map of the Kobuk area at the same scale as that used here. However, Spetzman's maps are unpublished. Transparent plastic overlays made from them are available through the Joint Federal-State Land Use Planning Commission, Anchorage, Alaska. The Alaska Forest Inventory (Hutchison, 1967) includes an Alaska Forest map showing the limits of forest in the Kobuk. Viereck (in Viereck and Little, 1972) condensed and revised Spetzman's 1963 map but at half the scale of 1:5,000,000. In 1973 the Joint Federal-State Land Use Planning Commission for Alaska published a 1:2,5000,000 scale map, Major Ecosystems of Alaska, that appears to be a copy of Spetzman's map as revised by Viereck. It features an ecosystem-oriented terminology. On this map, our study area is mapped with a strip of bottomland spruce-poplar forest along the river bordered on either side by lowland spruce-hardwood forest in the valley that is replaced by upland spruce-hardwood forest on the slopes of the Baird and Waring

Mountains with extensions up the valleys of tributaries. The heads of these Baird Mountain tributaries are shown to have high brush and the surrounding mountains are shown to be covered with alpine tundra. The Great Kobuk Dunes are mapped as alpine tundra and there is a patch of wet tundra mapped just south of the Kobuk across from the mouth of the Hunt River.

Latitudinal tree line is reached within the Kobuk study area on the south slope of the Baird Mountains. Hustich (1953) characterizes the forest-tundra ecotone as a transition region where tundra occupies a large area and forests occur mainly along the rivers, in sheltered valleys and on southern slopes. Britton (1957) argues for the recognition of a third vegetation zone representing this transition. Others have described the forest-tundra ecotone elsewhere in Alaska (Griggs, 1934), in the Firth River of Canada (Drew and Shanks, 1965), Hudson Bay (Marr, 1948), and in Labrador (Hustich, 1951). In the present report an effort was made to accurately map the distribution of forest in this transition area.

Two studies, designed to investigate the effects and utilization of vegetation by caribou and reindeer, have been conducted within the Kobuk valley. Hanson (1953) characterized and classified vegetation types in northwestern Alaska in conjunction with surveys of reindeer winter lichen range and Pegau (Hemming and Pegau, 1970) built a caribou exclosure and described the vegetation at a site 19 km south southwest of Ambler in 1969.

Many valuable collections and observations of the flora and vegetation of the Kobuk were made in conjunction with archeological and dendrochronological studies. In 1940, Giddings (1941, 1973) collected tree cores at 15 sites in the Kobuk valley. Between 1967 and 1969 botanical studies were carried out at Onion Portage, located near the eastern edge of our study area, in association with archeological excavations. Here, Charles Schweger[2] collected about 187 species of vascular plants and studied vegetation and soils along a forest to tundra transect (letter dated November 4, 1974, University of Alberta). Schweger's main concern was the paleoecology of the area during the time that Onion Portage was occupied by cultures whose artifacts were revealed in a stratified site (cf. Anderson, 1968) Sten Florin of the University of Uppsala also made pollen collections from these strata but unfortunately he suffered a severe stroke and was unable to complete his work.

In Schweger's reconstruction of the Kobuk vegetational history at Onion Portage, there is evidence that spruce forest is presently at a peak having entered the area about 5,000 to 6,000 years ago. Before

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[2]Schweger, C. E. (in draft) Late Quaternary paleoecology of the Onion Portage region, northwestern Alaska. Ph.D. Thesis, Univ. Alberta, Edmonton, Alberta, Canada.

this time, between 6,000 and 10,000 years ago, there was a birch shrub-tussock tundra similar to that occupying a large part of the area today. Finally, from about 12,000 to 10,000 years ago the area was covered with high arctic herb tundra similar to that in the arctic coastal plain. The vegetational record is obscured by unconformities back to the mid-Wisconsin where there is evidence for a steppe tundra with *Artemisia* spp. and grasses.

The present study of the proposed Kobuk Valley National Monument (KVNM) represents an addition to several recent botanical studies made in northwestern Alaska and the Brooks Range on lands that were set aside as national interest lands under the Alaska Native Claims Settlement Act (ANCSA), section 17 d-2. Young (1974) described the flora and vegetation of the Noatak River watershed. He found there an exceedingly rich flora more characteristic of tundra than boreal forest. Racine (1974) surveyed the flora and vegetation of the proposed Chukchi-Imuruk National Reserve on the Seward Peninsula and David and Barbara Murray[3] described the flora of the proposed Gates of the Arctic National Park (GANP) located east of the proposed KVNM study area. Although the boundaries of the proposed GANP include Walker Lake and the surrounding headwaters of the Kobuk River, the Murray's did not visit the upper Kobuk valley during their study.

METHODS

The flora and vegetation of the Kobuk valley were studied in the field between July 18 and August 27, 1974. Plant collections, observations, and vegetation samples were made along the Kobuk River, the Salmon River, and on the lower reaches of the Kallarichuk, the Kaligaricheark, the Hunt, and the Akillik Rivers. At base camps on the Great Kobuk Sand Dunes and on a small lake in the Baird Mountain foothills I made more extensive collections and observations. Because of the inaccessibility of the high mountains, upper valleys, and headwaters of tributary streams, detailed botanical information for these areas was not obtained.

The lateness of the field season precluded our making comprehensive collections of flowering specimens. Therefore, I concentrated on collecting rare or unusual plants and those in flower. Notes were made on the presence and location of all species observed, but particular care was given to recording the distribution of species characteristic

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[3]Murray, D. F. and B. M. Murray. 1974. Notes on the botany at selected localities on the Alatna and Killik Rivers, central Brooks Range, Alaska. Final Report of Gates of the Arctic vegetation study, Project for U.S. National Park Service. Xerox, Univ. Alaska Museum, Fairbanks, Alaska. (Copies available for review at Univ. Alaska Museum and Coop. Park Studies Unit and at National Park Service offices, Anchorage, Alaska.)

of the boreal forest in relation to altitude, latitude, and the east-west gradient down river from the interior toward the coast. Particular attention was given to the flora of the Great Kobuk Sand Dunes, other areas of unstable dunes, and to the aquatic and bog floras. Collections were processed at the University of Alaska herbarium. Several leguminous specimens from the Kobuk Sand Dunes were sent to Dr. Rupert Barneby at the New York Botanical Gardens for identification. Hulten (1968) included collections from around Kiana, Ambler, and Walker Lake in constructing his distribution maps. In the present study his work is used as the authority for all plant names except for willows. Argus (1973) has been used for these.

Vegetation was studied, classified, described, and mapped with the aid of ground and aerial reconnaissance, quadrat sampling, ERTS Satellite imagery, and 1:5,000 scale aerial photos selected from the Forest Inventory Study of Alaska (Hutchison, 1967). Species lists and subjective estimates of importance were recorded. In addition, 20 quantitative stand samples were taken in both forest and nonforest vegetation types. Sampling of forest and woodland was carried out in 10 m x 10 m plots placed in stands that were subjectively chosen to represent a particular forest vegetation type. Within a plot, the heights and diameters of all tree stems greater than 2.5 cm dbh (diameter breast height) were determined, canopy cover was estimated and the species composition of the tall shrub, low-medium shrub, and herd strata was determined. The largest diameter tree (and often the smallest) in the plot was cored to determine age and growth rate. The resulting data were used to determine the basal area and density for each tree species in each plot. Herbaceous and dwarf shrub vegetation was sampled using the quadrat technique employed by P. J. Webber (University of Colorado) in his U.S. I.B.P. Tundra Biome vegetation studies. Each stand was sampled with 10 continguous 1 m x 1 m quadrats. In each quadrat species presence was recorded and relative cover for each species was visually estimated in a .1 m x 1 m strip along one side of each quadrat. From these samples, values for relative cover and relative frequency were calculated for each species and combined into an importance value.

An Earth Resources Technology Satellite (ERTS) image taken on June 18, 1973 was enlarged to a scale of 1:250,000 in simulated color-infrared format and mounted on a board, covered with plastic and used in the field to assign vegetation types to the various color signatures. Interpretations were based on the assumption that the colors represented the spectral reflectance of different vegetation types. This was generally found to be the case in the field. A black and white winter ERTS scene taken in March 1973 helped show the distribution of certain dominant plant growth forms. Because of the snow cover, fairly dense coniferous spruce forest appears as dark areas distinguishable from white or grey snow covered areas with vegetation of low or more open stature. These ERTS images were useful in mapping the vegetation of the valleys at lower elevations, but because much of the mountains were

either in cloud shadows or covered by snow, mapping of higher elevation vegetation was difficult. Extensive aerial reconnaissance into the Baird Mountains permitted the more accurate mapping of these areas. Final preparation of the map was done following the field season using the methods outlined by Anderson (1974). Briefly, a plastic overlay was placed over the U.S.G.S. topographic maps and prominent landmarks such as stream courses were traced upon the overlay. The plastic was then positioned over the ERTS image and the vegetation units were drawn onto it. Finally the vegetation boundaries mapped on the plastic overlay were traced onto the U.S.G.S. topographic base maps and zipatone shading was applied to represent the different vegetation types.

RESULTS AND DISCUSSION

FLORA

About 260 species of vascular plants were collected or observed in the study area (Appendix I). The flora may be much larger. Only limited collections were made at high elevations and in areas of limestone and serpentine rocks. Thus, many species may have been bypassed. Young (1974) described a flora of about 440 species in the Noatak drainage to the north; however this area is about 4 times the size of our Kobuk study area and encompasses a wider range of habitats. Because of its small size and interior position, the Kobuk study area may actually contain a relatively small flora of less than 300 species. Shetler (see footnote 1) estimated the flora at Redstone and Walker Lakes to contain about 225 species and Schweger (pers. comm.) collected 187 species in the Onion Portage area. Since the Kobuk study area lies in the ecotone between the tundra and boreal floristic zones, the floras of each are attenuated. However, the flora is particularly depauperate in arctic and alpine tundra species. For example, the low diversity of *Saxifraga* spp. was striking in the Kobuk study area in comparison with the high diversity of *Saxifraga* spp. in the tundra of the Seward Peninsula (Racine, 1974) and in the upper Noatak (see footnote 1). Certain habitats, which frequently contain rich floristic assemblages of arctic and alpine species, were rare, absent, or inaccessible in the study area. The rich floristic assemblages associated with persistent snowbanks in some areas were not seen in the Baird Mountains. Indeed, above tree line the mountains were strikingly bare, dry, and rocky, and lacked lush alpine meadows common to other mountainous areas. Based on limited field experience at the higher elevations in the Kobuk, it is difficult to state, as Young has done for the Noatak, that "virtually every type of arctic habitat is found somewhere in the Noatak Drainage, and in most cases these habitats support a full complement of both circumpolar species and Beringian endemics". The Noatak lacks typical examples of the boreal forest biome (Young, 1974). Similarly, typical tundras appear to be poorly represented in the proposed Kobuk Valley National Monument area.

Range Extensions

Table 1 lists species whose presence in the Kobuk study area represent a range extension of at least 161 km compared with the distributions shown in Hulten (1968). Most of these are species characteristic of the interior Alaska boreal forest and represent west, north, and northwest extensions of their previously known range. Most of these species were collected only once indicating that they were uncommon in the Kobuk valley study area. Examples are *Myrica gale*, *Equisetum silvaticum*, and *Geocaulon lividum*. Other species, such as *Moneses uniflora*, *Utricularia minor*, *Cryptogramma Stelleri*, *Saxifraga spicata*, and *Plantago canescens*, occur north of the Kobuk valley to the Noatak drainage where they are very rare (Young, 1974).

Only one species, *Papaver Walpolei*, which was collected recently in the Noatak delta (Young, 1974) and even in the Yukon (Hulten, 1973), represents an eastward range extension from the coastal Bering Strait region. This is surprising in view of the presence of sand dunes in the Kobuk valley which might support coastal dune species. The absence of eastward range extensions in the Kobuk may also be an artifact of limited collecting in the mountains. While Young (1974) found *Veratrum album*, a Eurasian species occurring on the Seward Peninsula, to extend eastward into the Noatak valley, it was not encountered in the Kobuk. The distribution of another species, *Asplenium viride*, appears to be more extensive in northwestern Alaska than previously thought.

Bugseed (*Corispermum hyssopifolium*) is a weedy annual plant of sandy areas and has a sporadic but worldwide distribution pattern. Around the Great Lakes and along the Atlantic coast it is common on sandy beaches and mobile dunes. Hulten (1968) shows it to occur in Alaska along the Yukon River from which it has apparently spread to the Kobuk valley where it is confined to sandy areas along the river. At Onion Portage, at the Hunt River Dunes and at Point Goldie, it occurs in large numbers and its transport to the Great Kobuk Dunes would undoubtedly result in a tremendous population explosion and a threat to the pioneer species already there.

Habitats of Special Interest

Cliffs along the Salmon River, bogs or marshes and mobile sand dunes require additional study because they contain rare plants representing range extensions or they support a rich or unusual flora.

Reddish sandstone and dark grey phyllite cliffs (I. Tailleur, U.S. Geological Survey, Menlo Park, Calif., pers. comm.) 8 to 12 m high, rise above the lower Salmon River (Fig. 1). A rich and unique assemblage of plant species grow in the moist, shaded crevices and foliations of the phyllite cliffs. *Saxifraga spicata*, *Thalictrum sparsiflorum*, and the

Table 1. Range extensions of vascular plants collected in the proposed Kobuk Valley National Monument area. Except as noted, plants were collected during the 1974 field season. Species listed represent range extensions of at least 161 km based on Hulten's 1968 range maps.

Species	Extends Range
Myrica gale	northwestward
Equisetum silvaticum[2]	slightly northward
Utricularia minor	westward
Spiranthes Romanzoffiana	westward
Platanthera hyperborea	westward
Cryptogramma Stelleri	northwestward
Geocaulon lividum[1,2,4]	westward
Cicuta mackenzieana	northward
Asplenium viride[3]	northward
Corispermum hyssopifolium[1]	northwestward
Saxifraga spicata	westward
Moneses uniflora[2]	northwestward
Drosera anglica[2]	northward
Goodyera repens	northwestward
Galium trifidum	westward
Plantago canescens	westward
Papaver Walpolei	eastward
Oxytropis viscida	westward
Trientalis europaea[2]	northeastward
Thalictrum sparsiflorum[2]	northwestward
Delphinium glaucum[1]	northwestward
Delphinium brachycentrum	southwestward
Viburnum edule	westward

[1]Collected at Onion Portage by C. Schweger, University of Alberta, 1967-69.

[2]Collected at Redstone Lake, Kobuk River tributary by S. Shetler, Smithsonian.

[3]Collected at Walker Lake on the upper Kobuk by S. Shetler, Smithsonian, 1963.

[4]Collected at Little Kobuk Sand Dunes by H. R. Melchior, University of Alaska, 1973.

Figure 1. Phyllite cliffs along the Salmon River.

ferns _Asplenium viride_ and _Cryptogramma Stelleri_ grow here along with other herbs such as _Potentilla uniflora_, _Draba palanderiana_, _Lycopodium_ spp., _Dryopteris fragrans_, _Woodsia alpina_, and _Cystopteris fragilis_. The fern flora of the Kobuk valley reaches its greatest diversity on these cliffs. Shetler (see footnote 1) was impressed by the fern flora of the upper Kobuk valley at Redstone and Walker Lakes noting that it was richer there than in the upper Noatak tundra region. He thought the flora was indicative of more mesophytic conditions than are found in the interior and exhibited closer floristic affinities with the Bering Sea and Pacific coastal regions than with interior spruce forests.

A second habitat type supporting rare species is the aquatic bog or marsh. This type is best developed in areas of old river meanders and in swales between sandy ridges of the Hunt River Dunes (Fig. 2). Plant species characteristic of interior Alaska bogs were found here including _Myrica gale_, _Cicuta mackenzieana_, _Drosera anglica_, and _Utricularia minor_.

Finally, the three areas of active sand dunes (Fig. 3) contain a large and unique flora which needs additional study. Specimens of many species here vary strikingly from the typical forms and it seems likely that many species populations have existed in isolation on these dunes for long enough periods of time to diverge in a number of characters. Because of the difficulties in identifying several specimens of leguminous plants collected on the Great Kobuk Dunes, they were sent to Dr. Rupert Barneby at the New York Botanical Garden. In a letter to me dated January 15, 1975 he wrote: "I've never seen anything quite exactly like the dune _Astragalus_ before, but I've persuaded myself that it must be an ecotype of the highly polymorphic _A. alpinus_." A sand dune species of _Oxytropis_, _O. kobukensis_ has diverged enough to be recognized as a distinct species (Walsh, 1967). It is the only plant species known to be endemic to the Kobuk study area. Its distribution, apparently restricted to these unstable dune areas, suggests that it evolved there. This silvery robust legume with large purple-pink flowers (Fig. 4) grows on the open, shifting sands and its elongated base may be an adaptation to burial by sand. It was collected at both the Hunt River and Great Kobuk dune fields but it is not known whether or not it occurs on the Little Kobuk Dunes. _Oxytropis kobukensis_ was originally collected by R. D. Hamilton on 5 July 1938 and later by Charles Schweger at the Hunt River Dunes. When Walsh (1967) first described this species he stated that its distribution was restricted to the Hunt River Dunes, but specimens I collected at the Great Kobuk Dunes during the 1974 field season shows that it occurs here also. However, while _O. kobukensis_ was flowering profusely on the Hunt River Dunes on August 11, 1974, only one flowering specimen could be found on the Great Kobuk Dunes 1 week later. Plants in the two dune areas may have different flowering times.

In the spruce forests bordering the dunes or streams passing through the dunes, interior Alaskan species such as _Geocaulon lividum_ and _Goodyera repens_ were found. A stabilized sandy flat or stream

Figure 2. Bog near the Hunt River Dunes.

Figure 3. Aerial view looking south across the Kobuk River where it is joined by the Hunt River. Both the Hunt River Dunes (foreground) and the Great Kobuk Dunes (background) are visible.

Figure 4. Oxytropis kobukensis growing on the mobile sand of the Great Kobuk Dunes.

terrace by Ahnewetut Creek contained the richest assemblage of species encountered in the study area. At least 30 dwarf shrub and herbaceous species were found including mountain species such as Saxifraga oppositifolia and Thalictrum alpinum which grew here at an elevation of only 60 m. See the special section on the Kobuk Sand Dune flora and vegetation for a more detailed discussion.

Phytogeographical Relationships

For most purposes, the Kobuk valley can be viewed as the northern- and western-most limit for many species typical of the boreal forest. Young (1974), commenting on the flora and vegetation in the Noatak River valley said "there are few or no areas which are truly representative of the typical boreal forest biome." Many boreal species, which occur in the Kobuk, do not reach the forested areas of the Noatak watershed; these include black spruce (Picea mariana), aspen (Populus tremuloides), yellow water lily (Nuphar polysepalum), Myrica gale, Geocaulon lividum and Polygonum alaskanum. Species such as Arctostaphylos uva-ursi and Rosa acicularis, which are common in the Kobuk, are extremely rare in the Noatak. The major route of migration and connection between the Noatak and Kobuk spruce forests is through the Squirrel River drainage that lies to the west of our study area. Although there are low passes into the Noatak drainage at the heads of several tributaries where spruce forest occurs, there appears to be little migration by these routes (cf. Dean and Chesemore, 1974).

Within the Kobuk area, boreal species of interior Alaska are confined mainly to the Kobuk valley on the south side of the river and on the eastern edge of the study area. Geocaulon lividum, for example, was found only in the Onion Portage and Little Kobuk Dunes area by Schweger and Melchior respectively, and species such as Myrica gale and Drosera spp. are limited to the eastern edge of the study area. Other evidence that the eastern edge of the study area represents a significant biogeographic boundary includes the abundance of aspen (Populus tremuloides) there (near Ambler) and its relative rareness to the west.

Many species of the mobile sand dune areas have closer affinities with high arctic alpine mountain floras than with coastal sand dunes or boreal floras. Such species include Kobresia myosuroides, Plantago canescens, Astragalus alpinus ssp. arcticus, Lesquerella arctica, Parrya nudicaulis, and Minuartia arctica. Only a few maritime coastal species that are common on coastal sand dunes to the west (Racine, 1974) such as Chrysanthemum bipinnatum, Elymus arenarius, and Armeria maritima occur here.

VEGETATION

The Kobuk valley study area exhibits several striking vegetational features including: (1) high areal ground cover of lichens in several

vegetation types. From the air the lichens appear as conspicuous white or yellow patches (Fig. 5). The relatively high lichen ground cover may result from the presence of well drained, coarse, often sandy soils (Fernald, 1964) and has important implications for wintering caribou; (2) the area lies in a forest-tundra ecotone where the altitudinal, northern and, to a limited extent, maritime tree lines are reached; (3) large parts of the area are subject to both forest and tundra fires so that fire has obviously exerted a strong influence on the vegetation patterns (see Melchior, Part I, this report); (4) oxbow channels, deposition of gravel, silt and sand and flooding near the Kobuk River results in a characteristic vegetation mosaic (Fig. 6). However, the flood plain vegetation mosaics described by Drury (1956) for other large Alaskan rivers, such as the Kuskokwim and Yukon, seem to be missing in the Kobuk valley. Sphagnum peats and bogs appear to be less important in the Kobuk floodplain than along other large rivers. Drury suggests that fires and coarse sediments that allow water to percolate through them combine to enhance the development of marshy fens rather than sphagnum peat which carpets most of the Kuskokwim flats.

Classification of Vegetation Types

The classification of Kobuk valley vegetation presented in Table 2 is based on a hierarchy of criteria by which progressively finer vegetational units are recognized. The largest (smallest scale) units are recognized on the basis of physiognomy or the growth form of the dominant or overstory plants (e.g. Forest, Scrub, Dwarf-scrub, Herb). These units are then subdivided on the basis of the species which dominate the overstory. Finally, in some instances, a third subdivision of vegetation type is made on the basis of dominant understory species. Table 2 lists the various plant communities in relation to the various physiographic-topographic regions of the study area. These vegetation types represent units to which an observer on the ground might assign vegetation stands. For purposes of vegetation mapping at a scale of 1:250,000, it is neither possible nor practical to map all of the types in Table 2. Some types are neither of sufficient size (areal extent) nor distinct enough spectrally to be recognized on the ERTS imagery. Therefore, it was sometimes necessary to combine several types to form a mapping unit that consists of two or more different physiognomic types each too small to map individually. Both the types in Table 2 and the mapped units are described below following the vegetation map.

Vegetation Map

The vegetation map of the middle Kobuk River valley resulting from the present study (Fig. 7) shows the distribution of 13 vegetation types. The areal extent of each type is given in Table 3. Nine of these units are mapped as relatively homogenous types while the remaining four are mosaics. In addition, several areas that could be dated or recognized as recent or old burns and covered with scrub or charred vegetation are mapped.

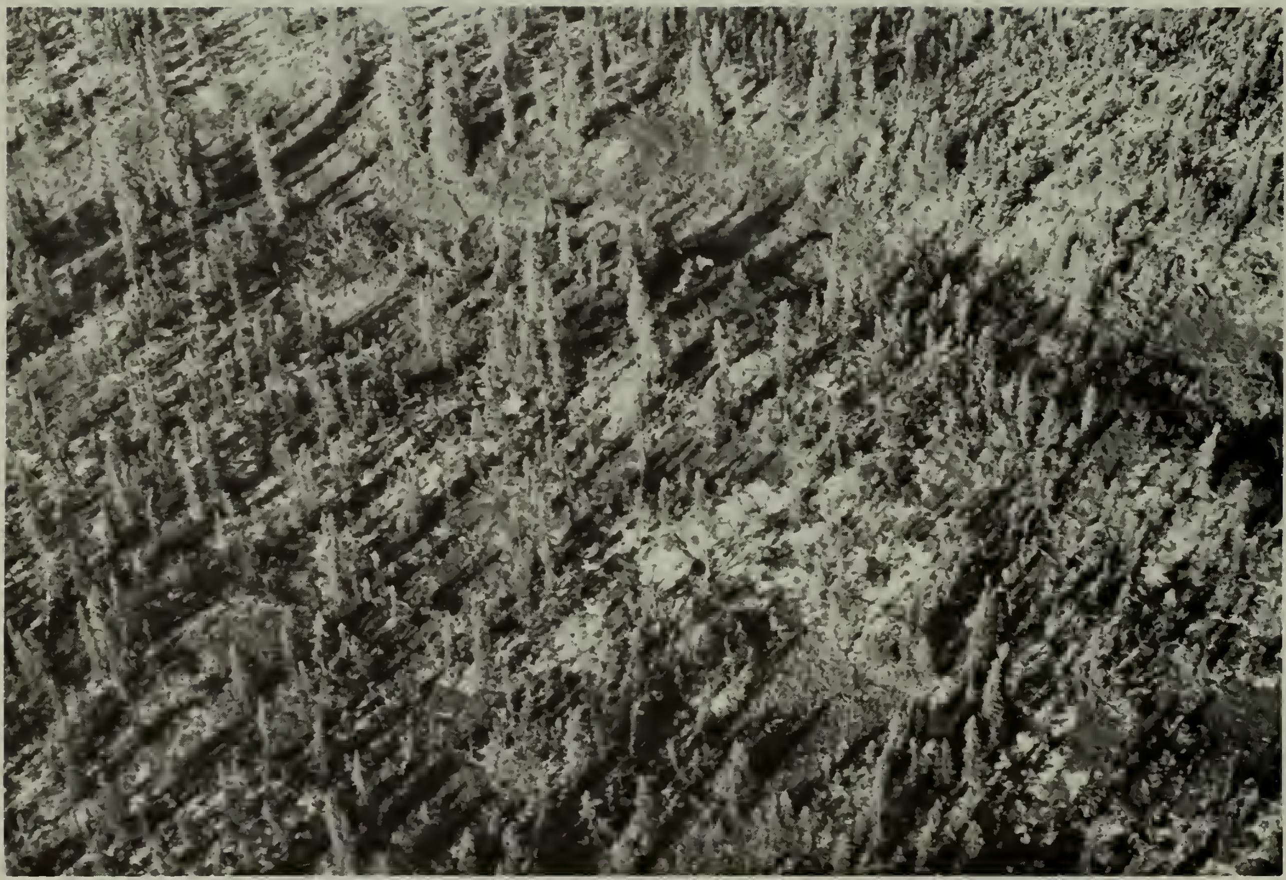

Figure 5. Light-colored patches of lichens are common south of the Kobuk River.

Figure 6. Meander patterns of the Kobuk River. Here, near Point Goldie, there is a mosaic of white spruce forest, black spruce woodland, willow scrub and sedge fen.

Table 2. Outline and classification of vegetation types recognized in the proposed Kobuk Valley National Monument area in relation to physiographic units.

	KOBUK RIVER VALLEY Bluffs and Knolls	Gravel Bars	Meander Stripes	Valley Lowlands	DUNEFIELDS Active, Unstable	Semistabilized	Stabilized	BAIRD MOUNTAINS Foothills	Trib. Valleys and Lower Slopes	Rock Cliffs	Drainageways	Alpine Peaks, Ridges and Upper Slopes	WARING MOUNTAINS Foothills and Lower Slopes	Alpine Peaks and Ridges	Drainageways	BURNS	LAKES AND PONDS
I. Forest and Woodland Types																	
1. Betula papyrifera																	
a. Alnus, Salix scrub	X							X					X				
b. Cladonia lichens							X										
2. Populus balsamifera		X			X				X								
3. Picea glauca																	
a. Salix, Alnus scrub	X		X					X	X		X		X				
b. Hylocomium moss	X		X										X				
c. Cladonia lichen							X										
4. Picea mariana																	
a. Vaccinium, Salix			X	X			X		X								
b. Cladonia lichen										X							
c. Burn				X									X			X	
II. Scrub and Scrubland Types																	
5. Alnus crispa																	
a. Sedge, Ledum				X								X					
b. Calamagrostis		X						X	X		X		X				
c. Polemonium		X									X				X		
6. Feltleaf Willow		X	X			X			X		X				X		
7. Greenleaf Willow		X	X							X	X				X	X	
8. Betula glandulosa			X	X			X			X							
III. Dwarf Scrub Types																	
9. Vaccinium, Ledum				X								X	X				
10. Dryas, lichens						X	X					X		X			
11. Betula nana										X		X		X			
IV. Herb Types																	
12. Sedge Tussocks				X					X								
13. Carex rostrata Fen			X														X
14. Calamagrostis, Forb		X		X													
15. Carex aquatilis			X	X											X		X
16. Carex bigelowii				X								X		X			
V. Barrens	X	X			X					X		X		X		X	
VI. Aquatic Types																	X

Table 3. Areal e
planime

Vegetation
1. Mountain Fel Meadows and
2. Alder Scrub
3. Spruce Fores
4. Tussock Tund
5. Spruce Woodl
6. Recent Burns
7. Willow, Alde Spruce Scrub
8. Heath Dwarf
9. Willow Scrub
10. Spruce Fores Fen on River
11. Mobile Sand
12. Lichen Woodl
13. Cottonwood F
TOTALS

Table 3. Areal extent of the major vegetation types based on planimetry of the vegetation map (Fig. 7).

Vegetation Type	Areal Extent (km^2)	Percent
1. Mountain Fellfields, Sedge Meadows and Barrens	3380	44
2. Alder Scrub and Scrubland	1330	17
3. Spruce Forest	875	11
4. Tussock Tundra	690	9
5. Spruce Woodland	446	6
6. Recent Burns	224	3
7. Willow, Alder, and Young Spruce Scrub	152	2
8. Heath Dwarf Scrub	128	2
9. Willow Scrub	120	2
10. Spruce Forest and Sedge Fen on River Meanders	112	2
11. Mobile Sand Dunes	60	1
12. Lichen Woodland	58	1
13. Cottonwood Forest	34	<1
TOTALS	7609	100

This map can be used as an aid in making management and land use decisions relating to wildlife habitat, aesthetic features, and human subsistence activities. Coupled with estimates of primary production for each vegetation type, this vegetation map can provide an inventory of resource availability. Scientifically, the map can be used to guide future research, particularly in relation to vegetational change and changes in tree line at the northern boundary of the forest.

Description of the Vegetation Types

I. Forest and Woodland Types.

Although several tree species including paper birch, balsam poplar, aspen, black spruce, and white spruce occur in the study area, forest and woodland vegetation covers less than 25% of the region. Forest and woodland dominated by deciduous broadleaf species covers less than 2% of the proposed KVNM but becomes more extensive to the east of the study area. In the middle Kobuk valley, in contrast to interior Alaskan forests, aspen stands are rare and paper birch forest is restricted to specialized sites. Deciduous forest is best represented by balsam poplar stands adjacent to rivers. Evergreen conifer forest and woodlands, dominated by white or black spruce, are more widespread than deciduous forests. In all the forests of the area, tree density is low and stems are widely spaced so that woodland is a more accurate designation than forest. However, there is a continuum in the density and spacing of trees making any such division arbitrary.

Five forest types are recognized. Each is described with comments on distribution, structure, composition, herbivore, and subsistence uses and productivity.

1. _Betula papyrifera_ Forest and Woodland.

Paper birch is restricted to elevations below 152 m where it occurs on well-drained river bluffs and knolls and on slopes and ridges of the foothills of the Baird and Waring Mountains. Occasionally, paper birch is locally dominant on sandy, stabilized sand dunes. Unlike stands in interior Alaska, paper birch is seldom an important component of spruce forests.

Within the study area paper birch trees seldom exceed 25 cm dbh (dbh = diameter breast height), 12.2 m in height and 75 years in age (Table 4). Paper birch trees are often scrubby and multistemmed. Paper birch is near its limit of distribution in the Kobuk.

Two subtypes of paper birch forest can be recognized on the basis of structure and understory vegetation.

1a. _Betula papyrifera/Alnus_, _Salix_. A closed birch forest with a tall alder scrub understory develops on some dry slopes in the

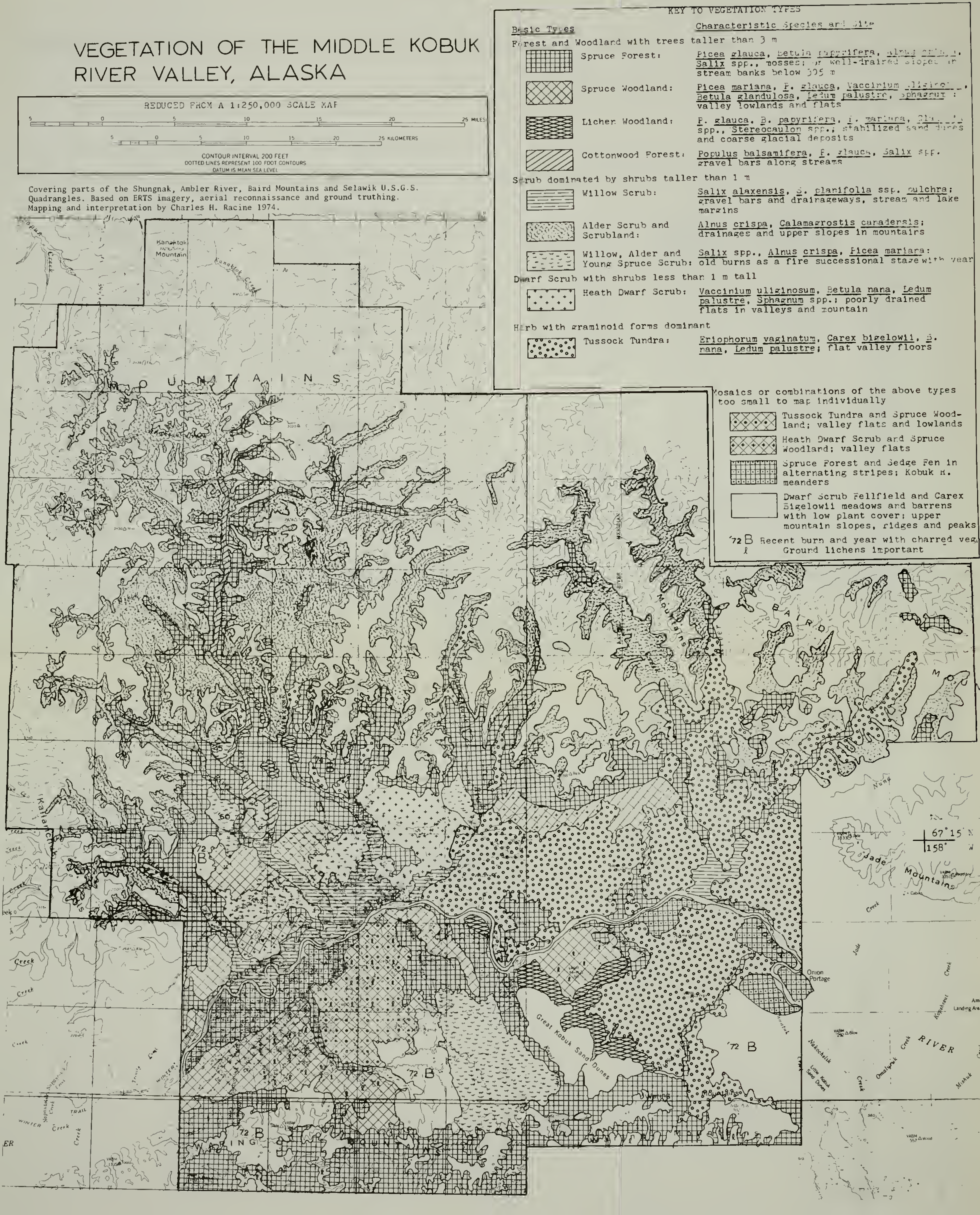
VEGETATION OF THE MIDDLE KOBUK RIVER VALLEY, ALASKA
REDUCED FROM A 1:250,000 SCALE MAP
5 0 5 10 15 20 25 MILES
5 0 5 10 15 20 25 KILOMETERS
CONTOUR INTERVAL 200 FEET
DOTTED LINES REPRESENT 100 FOOT CONTOURS
DATUM IS MEAN SEA LEVEL
Covering parts of the Shungnak, Ambler River, Baird Mountains and Selawik U.S.G.S. Quadrangles. Based on ERTS imagery, aerial reconnaissance and ground truthing. Mapping and interpretation by Charles H. Racine 1974.
KEY TO VEGETATION TYPES
Basic Types
Characteristic Species and Site
Forest and Woodland with trees taller than 3 m
Spruce Forest:
Picea glauca, Betula papyrifera, Salix spp., mosses; on well-drained slopes in stream banks below 305 m
Spruce Woodland:
Picea mariana, P. glauca, Vaccinium, Betula glandulosa, Ledum palustre, Sphagnum: valley lowlands and flats
Lichen Woodland:
P. glauca, B. papyrifera, P. mariana, spp., Stereocaulon spp.; stabilized sand dunes and coarse glacial deposits
Cottonwood Forest:
Populus balsamifera, P. glauca, Salix spp. gravel bars along streams
Scrub dominated by shrubs taller than 1 m
Willow Scrub:
Salix alaxensis, S. planifolia ssp. pulchra; gravel bars and drainageways, stream and lake margins
Alder Scrub and Scrubland:
Alnus crispa, Calamagrostis canadensis; drainages and upper slopes in mountains
Willow, Alder and Young Spruce Scrub:
Salix spp., Alnus crispa, Picea mariana: old burns as a fire successional stage with year
Dwarf Scrub with shrubs less than 1 m tall
Heath Dwarf Scrub:
Vaccinium uliginosum, Betula nana, Ledum palustre, Sphagnum spp.; poorly drained flats in valleys and mountain
Herb with graminoid forms dominant
Tussock Tundra:
Eriophorum vaginatum, Carex bigelowii, B. nana, Ledum palustre; flat valley floors
Mosaics or combinations of the above types too small to map individually
Tussock Tundra and Spruce Woodland; valley flats and lowlands
Heath Dwarf Scrub and Spruce Woodland; valley flats
Spruce Forest and Sedge Fen in alternating stripes; Kobuk R. meanders
Dwarf Scrub Fellfield and Carex bigelowii meadows and barrens with low plant cover; upper mountain slopes, ridges and peaks
'72 B Recent burn and year with charred veg.
Ground lichens important
M O U N T A I N S
BAIRD
Mountains
Kanaktok Mountain
Great Kobuk Sand Dunes
Little Kobuk Sand Dunes
Onion Portage
Jade Mountains
RIVER
Kallarichuk
Nakochalik
Ambler Landing Area
67°15' N
158° W
'72 B
'50
'35
TRAIL
WINTER
Creek

Table 4. Dominant species, location, site data, and structure of stands sampled in the proposed Kobuk Valley National Monument.

Stand	Dominant Species	Location	Elev. m	Aspect	Slope %	Canopy Height (m)	Total Basal Area $m^2/100\ m^2$ Quadrat	Stem Density per 100 m^2 Quadrat	Age of Largest Tree (yrs)
1	Picea glauca	Kobuk River	23	--	1	10.7	.165	10	190
2	Picea glauca	Salmon River	183	--	1	10.7	.143	7	266
3	Picea glauca	Salmon River	61	--	1	18.3	.427	5	100
4	Picea glauca	Kobuk River	46	--	1	15.2	.501	33	123
5	Picea glauca	Dunes	60	--	1	15.2	.451	16	135
6	Picea glauca	Dunes	64	--	1	7.3	.069	6	59
7	Picea glauca	Kobuk River	28	--	1	7.6	.079	8	70
8	Picea glauca - P. mariana	Kaliguricheark R.	27	--	1	9.1	.069	9	120
9	Picea mariana	Salmon River	185	SW	20	4.9	.068	24	194
10	Populus balsamifera	Salmon River	183	--	1	6.7	.191	30	80
11	Populus balsamifera	Salmon River	61	--	1	13.7	.258	19	88
12	Populus balsamifera	Akillik River	50	--	1	15.2	.315	10	
13	Betula papyrifera	Akillik River	48	E	38	7.6	.148	28	73
14	Betula papyrifera	Kobuk River	30	E	5	6.1	.061	8	59
15	Eriophorum vaginatum	Kaliguricheark R.	31	--	--				
16	Eriophorum vaginatum	Akillik River	52	--	--				
17	Vaccinium uliginosum	Waring Mountains	360						
18	Salix phlebophylla	Waring Mountains	380						
19	Lichens - Silene spp.	Gt. Kobuk Dunes							
20	Kobresia myosuroides	Gt. Kobuk Dunes							

foothills and on river bluffs (Fig. 8) where the trees reach their largest size in the study area (stand #13, Table 4). In addition to understory spruce saplings and alder, ground cover includes Spirea beauverdiana, Vaccinium vitis-idaea, V. uliginosum, and herbs such as Equisetum spp., Lycopodium annotinum, Carex spp., and mosses.

1b. Betula papyrifera/Cladonia lichens. The second subtype of birch forest occurs on stabilized dunes located south of the Kobuk River where spruce/lichen woodland is prevalent. Here, paper birch is usually a subordinate species in spruce/lichen woodland, but occasionally it becomes dominant as twisted trees with one to eight stems less than 7.6 m tall (Fig. 9). Single stems can reach 18 cm diameter but stems of multistemmed trees seldom exceed diameters of 7.6 cm. Stand #14 in Betula papyrifera/Cladonia lichen woodland by the Kobuk River contained 8 paper birch trees (a total of 17 stems) per 100 m^2. Total tree cover was 30% which is higher than cover in the surrounding spruce/lichen woodland. In these stands the only understory vegetation was a ground cover of fruticose lichens, which is described in more detail below in the discussion of spruce/lichen woodland. In the paper birch/lichen woodland, the lichen mat is poorly developed possibly as a result of increased cover of leaf and branch litter.

Most of the paper birch bark harvested by valley residents for basket construction is obtained upriver from the study area (Mark Cleveland, Ambler, Ak., pers. comm.) where paper birch reaches larger sizes. Giddings (1973) noted that birches became smaller and scrubbier below Black River, a tributary entering the Kobuk upriver from the study area. He also remarked that unusually large white birch trees were often good indicators of archeological sites. Girdled and stripped birch trees were observed within the study area attesting to past bark harvests. The effects of spring bark removal on living paper birch trees are unknown. However, it would seem to make these trees more susceptible to infection.

2. Populus balsamifera Forest.

Of the deciduous forest types, cottonwood-dominated stands are the most widespread and important type in the study area. They occupy river terraces and gravel bars as a stage in succession to white spruce forest (cf. Viereck, 1970). Cottonwood forest is not as well developed and conspicuous along the Kobuk River as it is along the Salmon River where fairly stable river banks and coarse sediments result in an almost continuous strip of cottonwood forest (with white spruce) extending up the valley almost to the headwaters (Figs. 10 and 11). Isolated groves of cottonwood occur in these valleys beyond the limits of spruce and up to about 600 m elevation. Cottonwood forest is more common on the north side of the Kobuk than on the south side where streams are too sluggish to form extensive gravel bars. However, there are occasional low shrubby cottonwood groves on the Great Kobuk Dunes and occasionally on bluffs along the Kobuk River.

Figure 8. Interior of a stand typical of the paper birch/alder forest type.

Figure 9. Paper birch/lichen woodland on stabilized dune surface.

Figure 10. View up the lower Salmon River valley showing the light-colored foliage of cottonwood along the river.

Figure 11. Well developed stand of cottonwood on gravel terrace by Salmon River. Note understory of white spruce and scrub.

Cottonwood dominated stands along the lower Salmon River contain trees up to 36 cm in diameter and 17 m in height; on the upper Salmon River, near Anaktok Creek the largest trees are about 17 cm dbh and 8 m high (stand #10; Table 5). Cottonwood trees form a fairly open canopy of about 40-60% cover above tall shrub, low shrub and herbaceous vegetation layers. There are usually scattered white spruce in the understory of young stands and in the overstory of 80-90 year old stands (stand #11; Fig. 12). In these older stands, up to 50% of the cottonwood trees may be dead but reproduction by sprouting is abundant. The tall shrub species present in these stands usually include degenerating *Salix alaxensis*, *S. lanata* spp. *richardsonii*, *S. glauca*, *S. hastata*, and *Alnus crispa*. Low shrubs such as *Viburnum edule*, *Rosa acicularis*, *Shepherdia canadensis* occur beneath the tall shrubs. Herbaceous ground cover includes species such as *Mertensia paniculata*, *Calamagrostis canadensis*, *Epilobium angustifolium*, *Anemone richardsonii*, *Rubus arcticus*, *Galium boreale*, *Aconitum delphinifolium*, *Equisetum pratense*, *Artemisia Tilesii*, and *Hedysarum alpinum*. These cottonwood stands represent one of the few habitats in which *Rubus arcticus* produced fruits. The Kobuk cottonwood forests below an elevation of 100 m are more similar in composition and structure to cottonwood-dominated stands in interior Alaska than they are to cottonwood groves in the Noatak valley (Young, 1974). Stands in the Noatak lack many of the species usually associated with the Kobuk and interior stands.

Valley residents do not use cottonwood extensively but a few, like Tommy Sheldon of Kiana, use it to smoke salmon (pers. comm.). Cottonwood trees make up much of the generally sparse driftwood along the river. On the middle sections of the Salmon River, where cottonwood forests are best developed (Fig. 11), bank beavers were cutting large trees next to the river (Fig. 13). Beaver had cut trees as small as 10 cm dbh and as large as 35 cm dbh but trees in the 10 to 20 cm dbh size classes were cut most frequently.

3. *Picea glauca* Forest and Woodland.

Although quite variable, white spruce forests are the most widespread of the forest types, covering about 11% of the study area. This type forms extensive stands on mountain slopes below 305 m, adjacent to rivers and streams, on broad meander stripes along the Kobuk River, and on stabilized sand dunes. White spruce is the principle timberline tree at the headwaters of tributary valleys in the Baird Mountains and it is known to extend into the lower Noatak valley and westward to the Kobuk delta. The most extensive white spruce forests occur on slopes along the west side of the study area in the Kallarichuk Hills bordering the Salmon River.

Of the various tree species in the valley, white spruce attains the largest sizes, up to 59 cm dbh and 24 m tall, along river banks and near sand dunes. Although white spruce trees are smaller at higher elevations, on the upper Salmon River there were individuals with

Figure 12. View of the interior of a cottonwood stand, Salmon River.

Figure 13. Cottonwood trees felled by bank beavers, Salmon River. (Photo by H. R. Melchior.)

diameters of 50 cm and heights of 13 m.

A very open stand of white spruce on a gradual south-facing slope above Anaktok Creek at about 215 m is one of the northernmost remnants of spruce forest within the Salmon River valley (Fig. 14). About 75% of the white spruce trees were dead, mostly as a result of porcupine damage. Young (1974) thought porcupines were an important cause of mortality of spruce in the Noatak valley. Of the living trees, often only the lower branches had needles. One of the largest trees in this stand was 104 years old, about 21 cm dbh and 9 m tall; it supported an abundant cone crop. Among the widely spaced white spruce trees, there were patches of densely layered black spruce (Picea mariana) about 2 m tall. The understory included willow (Salix lanata), birch (Betula gladulosa), Potentilla fruticosa, Spirea beauverdiana, Vaccinium uliginosum, Equisetum spp., Petasites frigida, Linnea borealis, Senecio lugens, and spruce seedlings. On Sheep Creek, another upper Salmon River tributary, spruce trees reached 25 cm in diameter and 12 m tall at 275 m elevation; porcupine damage was less than 25%. The vegetation map (Fig. 7) shows several stands of white spruce on the upper headwaters of the Akillik (Fig. 15), Hunt, Akiak, Tutuksuk, and Salmon Rivers which are disjunct from other valley and lowland stands. However, spruce stands in the Kobuk valley are not restricted to south slope exposures as they are in other areas (see footnote 1; Hustich, 1953). In the Kobuk valley some south slopes may be too dry for spruce growth.

On the basis of understory cover, three types of white spruce forest can be recognized. The most common and extensive type of white spruce forest has a fairly dense understory of tall alder and willow scrub. On some sites, a ground cover of mosses develop to form a white spruce/moss forest. In these two types, white spruce seldom occurs mixed with deciduous trees or even with black spruce but forms pure stands with an open overstory cover of 25-50%. On some Kobuk River bluff slopes and old gravel bars white birch and cottonwood respectively may be mixed with the dominant white spruce. A third white spruce subtype is an open woodland with a lichen ground cover.

3a. Picea glauca/Salix, Alnus. This subtype usually occurs on slopes and well drained river flats (stand #1; Fig. 16). White spruce trees are usually smaller in diameter and in height in this type than in the Picea glauca/moss type, however, this may be related to the greater age of the latter type as suggested by Viereck (1970). Alder (Alnus crispa) reaching heights of 2-3 m usually dominates the tall shrub strata, however, willows such as Salix glauca, S. lanata spp. richardsonii, S. alaxensis, and S. hastata are frequently present forming a cover of about 50%. Low shrubs such as Viburnum edule, Rosa acicularis, Spirea beauverdiana, Shepherdia canadensis, Vaccinium uliginosum, and Ribes triste are usually present, but like the herbaceous stratum, there is great variability in composition from stand to stand. Herbaceous ground flora includes Pyrola spp., Rubus chamaemorus, Boschniakia rossica, Aconitum delphinifolium, Linnea

Figure 14. One of the last spruce stands on a tributary, Anaktok Creek, of the upper Salmon River.

Figure 15. Spruce forest near the headwaters of the Akillik River.

Figure 16. Interior of stand #1 representative of the white spruce/ shrub subtype.

borealis, Equisetum spp., Mertensia paniculata, Primula stricta, and usually an orchid such as Platanthera hyperborea. In one stand, along the lower Kallarichuk River, both Trientalis europea and Cornus suecica were present.

3b. Picea glauca/moss Forest. In contrast to the subtype described above, white spruce/moss stands occur on protected, moist sites. White spruce reaches its largest size and highest basal area in stands of this type (stands #4 and 5; Fig. 17). Tall shrub cover is usually less than 20% and herbaceous species are usually replaced by a moss mat of Thuidium abietinum or Hylocomium splendens. On the flat top of a high bluff above the Kobuk River (stand #4), spruce trees up to 18 m tall formed a dense stand of 50% cover; but about one fourth of the canopy trees were dead. There were no tall shrubs. Herbs included Linnea borealis, Vaccinium vitis-idaea, Arctostaphylos alpina, Pyrola spp., Empetrum nigrum, Platanthera obtusata, and Artemisia Tilesii. In another stand (#5; Fig. 17) in dune hollows along Ahnewetut Creek where it cuts through the Great Kobuk Dunes, spruce trees reached 22 m in height although the tops of many trees were snapped off. In places these stands were being invaded by sand dunes. An orchid, Goodyera repens was found only in these white spruce/moss stands along Ahnewetut Creek.

3c. Picea glauca/Cladonia lichen Woodland. This subtype was best developed on gently rolling, stabilized sand dunes on the south side of the Kobuk River (Fig. 18). Stands along the north border of the unstablized Great Kobuk Dunes and on a bend in the Kobuk were visited and sampled (stands #6 and 7; Fig. 19). These open woodlands have only two strata; a tree layer of 10-20% cover with trees spaced 4.6 to 6 m apart and a thick lichen ground layer or mat that contrasts sharply with the dark spruce trees because of the bright yellow, white or gray color of the lichens. White spruce trees are generally small, usually less than 18 cm dbh and 10 m high and cores from the largest white spruce trees show only 60 rings. Occasionally black spruce or paper birch trees occur with white spruce (Fig. 19) but more often these species occur in localized patches. The density and basal area is greatly reduced over the other white spruce forest types. Stunted and normal trees of Populus tremuloides (Fig. 18) occur individually or in small groups. Dwarf shrubs such as Empetrum nigrum and Vaccinium vitis-idaea occur as dark patches in the lichen mat at the base of tree trunks (Fig. 19). There are occasional Vaccinium uliginosum dwarf shrubs and at the Great Kobuk Sand Dunes, Arctostaphylos uva-ursi is present. The composition of the lichen mat, up to 20 cm thick, varies, but species of fruticose lichens belonging to the genera Cladonia, Cladina, or Stereocaulon are most often dominant. Cladonia alpestris, C. rangiferina, and C. sylvatica are most important but Stereocaulon spp. locally forms gray mats and Cetraria cuculata, C. nivalis, Cornicularia divergens, Cladonia gracilis, Cetraria islandica, Nephroma arcticum, and Peltigera spp. are common associates.

Figure 17. Interior of stand #5, typical of the white spruce/moss subtype. This stand is adjacent to Ahnewetut Creek where it passes through the Great Kobuk Sand Dunes.

Figure 18. Sharp boundary between lichen woodland on left and spruce forest on right. Near a bend in the Kobuk River.

Figure 19. Interior of white spruce/lichen woodland.

Young (1974) did not find lichen woodland in the Noatak drainage. Lichen woodland is apparently best developed and most extensive in the forest-tundra ecotone of eastern Canada (Labrador) and Eurasia in glaciated regions (Hustich, 1951). Because of the well-drained substrate of the Kobuk Dune fields located near the northern limits of forest in Alaska, lichen woodland is well developed here (cf. Raup, 1946). In some areas it is an important habitat for wintering caribou and in Canada, fire can reduce the availability of lichens (Scotter, 1971). The 1973 ERTS satellite image indicates that fire recently burned lichen woodland areas near the Little Kobuk Dunes just outside the study area. Of the two lichen woodland areas visited during the field season, only one small area near the Great Kobuk Dunes showed evidence of ground fire. In Alaska, both reindeer and caribou utilize lichens in winter (Pegau, 1968). Pegau reported an annual growth rate of 5.6 mm/year for _Cladonia_ lichens in northwest Alaska and in this study measurements on _Cladonia rangiferina_ in lichen woodland along the Kobuk showed a comparatively high average growth rate of 6.98 mm/year ($s = \pm 1.77$; $n=10$).

4. _Picea mariana_ Woodland.

Although black spruce is less abundant and less widespread than white spruce, it forms open woodland stands throughout the Kobuk valley study area. Since black spruce does not occur in the Noatak (Young, 1974), it reaches its northwestern limits in the Kobuk valley. Black spruce is most important on flat, poorly drained valley lowlands but it was found on slopes in the Salmon River valley to the limits of white spruce (see Anaktok Creek stand, Fig. 14). On several old burns, black spruce was found to be an important colonizer and it was often seen scattered in layered groups in dwarf shrub types. Along the upper Salmon River, black spruce was conspicuous along bends of the river where fine textured sediments were exposed (Fig. 20). These stream bank situations contrasted sharply with areas of coarse textured sediments where cottonwood or white spruce were dominant (Fig. 11). Also along the Salmon River, black spruce formed a lichen woodland on knolls, bluffs and morrainal ridges.

Black spruce occurs in open woodland stands with a tree cover of less than 25%. On the basis of understory vegetation, three types of black spruce woodland can be recognized.

4a. _Picea mariana/Vaccinium_, _Salix_. On poorly drained, usually flat areas, black spruce occurs with a dwarf shrub understory of _Vaccinium uliginosum_, _V. vitis-idaea_, _Ledum palustre_, and scattered taller shrubs such as _Salix lanata_ ssp. _richardsonii_, _Salix glauca_, _Alnus crispa_, and _Betula glandulosa_ (Fig. 21). Black spruce forms an open, uneven canopy less than 11 m tall (6 m tall on wetter sites) (Fig. 21); and tree diameters usually do not exceed 15 cm dbh. At higher elevations, trees are often multistemmed and layered (stand #9) and the ground surface is hummocky with sphagnum, _Rubus chamaemorus_, _Petasites_

Figure 20. Undercut bank along the Salmon River. Note fine-textured soil and sliding vegetation mat.

Figure 21. Interior of a black spruce/Vaccinium, Salix stand near the Kobuk River.

frigidus, and sedges. On wetter sites, understory species such as Chamadaphne calyculata, Potentilla fruticosa, Iris setosa, and Menyanthes trifoliata are common. Where white spruce and black spruce occur together, a denser 1.2 m to 3 m tall shrub layer of Salix lanata ssp. richardsonii, S. glauca, and Alnus crispa develops (stand #8).

4b. Picea mariana/Cladonia lichen Woodland. While white spruce is most often dominant in lichen woodland situated on sand substrates south of the Kobuk River, black spruce dominates lichen woodland on knolls, ridges, and bluff tops along the Salmon River north of the Kobuk. On these features of coarse textured sediments, black spruce are stunted, clumped, and layered (Fig. 22). Lichens between these dense patches of black spruce include Cladonia alpestris, C. gracilis, and C. rangiferina. Scattered patches of dense shrub birch occur also.

4c. Picea mariana burn. Black spruce was found to be the main colonizer of an old burn along the Salmon River (Fig. 23). Trees were widely spaced, 2 m - 5.5 m tall and 5-11 cm in diameter. One tree, 10 cm dbh and 4.6 m tall, was 29 years old suggesting that the fire occurred about 1945 and that black spruce grew very fast following this burn. Aspen (Populus tremuloides) up to 1 m tall grew between the black spruce, a surprising occurrence in view of the general rareness of aspen in the area. Ground cover included dwarf shrubs such as Vaccinium uliginosum, Ledum palustre, Empetrum nigrum, Spirea beauverdiana, the clubmoss Lycopodium annotinum, much Polytrichum moss, and cup forming Cladonia lichens.

Map Units

The forest and woodland types described above were regrouped into four units for the purpose of vegetation mapping. Forest and woodland mapping units include: (1) Spruce Forest. This combines types 3a (Picea glauca/Salix, Alnus) and type 3b (Picea glauca/moss). (2) Spruce Woodland. This is composed mainly of type 4a (Picea mariana/Vaccinium, Salix). In interior Alaska this type is sometimes called 'muskeg'. (3) Lichen Woodland. This unit is easily distinguished from others by the thick ground mat of fructicose lichens beneath an open canopy of either white spruce (type 1b, Picea glauca/Cladonia lichens), paper birch (type 3c, Betula papyrifera/Cladonia lichens), or black spruce (type 4b, Picea mariana/Cladonia lichens). (4) Cottonwood Forest (Populus balsamifera) is the only deciduous forest type of sufficient extent to be mapped using ERTS imagery. One other forest and woodland type 4c (Picea mariana/burn) is included in the Willow, Alder, and Young Spruce Scrub mapping unit on old burns.

II. Scrub Types.

About 20% of the study area is covered with scrub dominated by shrubs from 1 to 10 m tall. In some areas, Salix alaxensis reaches tree

Figure 22. Black spruce/lichen woodland.

Figure 23. Old burn colonized by black spruce 25-30 years old.

heights of 10 m making the distinction between scrub and forest arbitrary. Because of the dominance by young trees and shrubs, many of the recently burned areas are classified as scrub vegetation although forest will develop. Dominant shrub species of the various scrub types include alder (Alnus crispa), which covers large areas in the mountains, and willows, which are important mainly at lower elevations on gravel bars, small stream drainages, and borders of lakes or ponds. Occasionally Betula glandulosa shrubs are dominant on rocky slopes and ridges.

5. Alnus crispa Scrub and Scrubland.

This is the most extensive scrub type. It covers 17% of the study area, mainly in the Baird Mountains where it forms either dense scrub, in drainageways and on lower slopes, or open scrubland on exposed slopes above tree line. While spruce forest reaches an elevation of 305 m on these mountain slopes, alder scrubland extends up to about 457-610 m (Fig. 24). In the Waring Mountains, alder scrubland forms a very narrow zone between spruce forest and alpine tundra.

5a. Alnus crispa/Sedge, Ledum Scrubland. On a 33% ENE facing slope in the Baird Mountains on the upper Salmon River (Fig. 25), 1.2-1.8 m tall alder shrubs were scattered 4.6 to 6.1 m apart with hummocky intervening ground. Associated herbs included Carex bigelowii and Calamagrostis canadensis. Dwarf shrubs such as Betula nana, Ledum palustre, Vaccinium uliginosum, and low-growing Salix planifolia ssp. pulchra were there also.

5b. Alnus crispa/Calamagrostis Chevrons. In the Hunt River drainage we observed dark green stripes of alder alternating with stripes of light green meadow (possibly Calamagrostis canadensis) lying at an oblique angle to the contours (Fig. 26). These features occurred most frequently in the Baird Mountains on steep upper slopes of small drainageways. The details of their composition and structure as well as their origin and maintenance requires more study.

5c. Alnus crispa/Polemonium Scrub. In mountain drainageways and occasionally along streams in the Kobuk valley, alder formed dense thickets up to 4.6 m tall with a sparse understory of Polemonium acutiflorum, Calamagrostis canadensis, Rubus arcticus, Mertensia paniculata, Ribes triste, and Spirea beauverdiana.

6. Feltleaf Willow Scrub.

This type covers islands and extensive flats along the Kobuk River (Fig. 27) and along the tributary streams that flow into the Kobuk from the north. Meandering, frequent flooding, and the deposition of sand and gravel provide substrates for colonization by fast growing willows, usually feltleaf willow (Salix alaxensis). The willows vary from 3 to 10 m tall with the tallest stands containing many dead stems. Ground

Figure 24. Zonation of spruce forest, alder scrubland, and alpine tundra on a slope above the Tutuksuk River.

Figure 25. Alder scrubland on facing slope (Anaktok Creek in background). Dryas, Lichen Dwarf Scrub type on ridges.

Figure 26. Chevrons of alder scrub strips alternating with an herbaceous type on a slope in the upper Hunt River drainage.

Figure 27. Feltleaf Willow Scrub along the banks of the Salmon River near the Kobuk River. The river was high on July 30 when this picture was taken.

cover beneath the willows includes Calamagrostis canadensis, Equisetum ssp., Aster sibiricus, Artemisia Tilesii, and, where the soils are sandy, additional herbs such as Chrysanthemum bipinnatum, Castilleja caudata, Polemonium acutiflorum, Parnassia palustris, and Hedysarum alpinum. Cottonwood seedlings or saplings are common in these tall willow stands as are other willow species such as S. lanata ssp. richardsonii, S. planifolia ssp. pulchra, and S. glauca.

7. Greenleaf Willow Scrub.

Willow thickets less than 3 m tall are widespread and occur along the bends of smaller tributary streams and drainageways, around lakes or sedge fens, on river meanders, and at the bottoms of some sand dune depressions. These areas are generally more stable and less subject to flooding than those where feltleaf willow is dominant. On the south side of the Kobuk, some slow moving streams appear choked with low willow thickets (Fig. 28). Species such as Salix planifolia ssp. pulchra, S. glauca, and S. lanata ssp. richardsonii occur singly or in mixed stands. Drainageways at lower elevations in the mountains are usually bordered by Salix planifolia ssp. pulchra. Alder and Salix alaxensis are sometimes present and the herbaceous understory includes Mertensia paniiiculata, Hedysarum alpinum , Galium boreale, and Arctostaphylos alpina.

8. Betula glandulosa Scrub.

This scrub type, which is dominated by scrub birch (Betula glandulosa) about 1.4 m tall, has a very restricted distribution. Birch scrub occurs on the tops of some cliffs along the upper Salmon River (Fig. 29) and in some low boggy areas in the Kobuk River valley. On rocky cliff tops and slopes in the Baird Mountains the birch cover is broken in places so that a ground cover of lichens, Ledum palustre and Vaccinium uliginosum develops. In some bogs near the Hunt River Dunes, Betula glandulosa forms parallel rows in a strongmoor.

Map Units

The scrub and scrubland types were recombined into three types for purposes of vegetation mapping. These mapping units include: (1) Willow Scrub. This includes both type 6 (Feltleaf Willow Scrub) and type 7 (Greenleaf Willow Scrub). (2) Alder Scrub and Scrubland. This is composed of types 5a (Alnus crispa/Sedge, Ledum), 5b (Alnus crispa/Calamagrostis), and 5c (Alnus crispa/Polemonium). (3) Willow, Alder, and Young Spruce Scrub. This is type 4c (Picea mariana/Burn). This third mapping unit develops in the valley lowlands and on lower mountain slopes after forest fires. Saplings and poles of black spruce and occasionally white spruce form fairly open stands with willows, alder, lichens, and mosses as a stage in the recovery from fire. On the ERTS image these areas are easily distinguished from areas of recent fires (within the past 3-5 years) by the absence of black, charred vegetation.

Figure 28. Greenleaf Willow Scrub type along slow-moving stream south of the Kobuk River. Note beaver dam in lower center of photograph. Dryas, Lichen Dwarf Scrub vegetation occupies hill tops in upper left.

Figure 29. Betula gladulosa Scrub on a high hill above the Salmon River.

III. Dwarf Scrub Types.

Low shrubs less than 1 m tall are dominant over large areas in both the Kobuk lowlands and on rocky mountain slopes, ridges, and summits.

9. Vaccinium, Ledum Dwarf Scrub.

On wet boggy flats away from the river and on poorly drained mountain slopes (stand #17), a fairly dense cover of blueberry (Vaccinium uliginosum), Betula nana, Sphagnum spp., Vaccinium vitis-idaea, Empetrum nigrum, Ledum palustre, and Rubus chamaemorus develops over hummocky ground. Low Salix planifolia ssp. pulchra, clumps of stunted black spruce and Carex bigelowii tussocks, that appear to be senescent, are sometimes present (Fig. 30). Lichen cover is often as high as 30% in places and consists of Cetraria cucculata, C. islandica, Cladonia gracilis, C. rangiferina, and C. sylvatica. The blueberry type merges into herbaceous tussock types at one extreme and into black spruce woodland at the other.

10. Dryas, Lichen Dwarf Scrub.

Prostrate dwarf shrubs are dominant on some sparsely vegetated, dry, rocky ridges, and peaks in the Baird and Waring Mountains and also on some dune areas (see Dune section). This vegetation type is extensive. It accounts for a large proportion of the alpine vegetation mosaic that occupies about 43% of the study area. Alpine areas in the Baird Mountains above 600 m are uncommonly dry and barren in comparison with other Alaskan montane areas and the Noatak valley (Young, 1974). Dryas octopetala and Salix phlebophylla are characteristic dwarf shrubs of rocky fellfields in the Waring Mountains (stand #18; Fig. 31). However, lichens cover up to 30% of the ground (Fig. 32) and there are many associates such as Oxytropis nigrescens, Anemone narcissiflora, Festuca rubra, Arctostaphylos alpina, Arnica spp., Artemisia arctica, Diapensia lapponica, Loiseleuria procumbens, Minuartia arctica, and Cassiope tetragona. On the south-facing slopes of the Waring Mountains fruticose lichens fill in between the dwarf shrubs to form long lichen-covered ridges (Fig. 32). In some places plant cover is as low as 10% or less, particuarly on limestone slopes in the Baird Mountains (Fig. 15). The Dryas, Lichen Dwarf Scrub type also occurs on sandy lowland dune flats and low hills as can be seen in the upper left hand corner of Figure 28. The caribou exclosures built by Hemming and Pegau (1970) are in Dryas, Lichen Dwarf Scrub stands southwest of Ambler and just east of the study area near the location of Figure 28. Although lichens cover much of the ground, dwarf shrubs include Loiseleuria procumbens, Ledum palustre, Empetrum nigrum, and Vaccinium vitis-idaea. Up to 32 species of lichens occur in this type including Cetraria nivalis, C. cucculata, Cornicularia divergens, and Cladonia spp. as dominants. On the Great Kobuk Sand Dunes, lichens and dwarf shrubs such as Dryas integrifolia, Arctostaphylos alpina, and A. uva-ursi are often important early colonizers of some dune surfaces.

Figure 30. Scattered black spruce in a dwarf scrub matrix.

Figure 31. Dryas, Lichen Dwarf Scrub along the crest of the Waring Mountains. View to the north shows the broad Kobuk valley, Great Kobuk Sand Dunes, and Baird Mountains.

Figure 32. Ridges on the south slope of the Waring Mountains covered with Dryas, Lichen Dwarf Scrub.

11. Betula nana Dwarf Scrub.

A dwarf scrub type dominated by Betula nana occurs locally in the mountains on the shoulder of ridges and cliffs that border barren areas.

Map Units

Of the three dwarf scrub types, only type 9 (Vaccinium, Ledum Dwarf Scrub) was mapped (as Heath Dwarf Scrub). However, type 9 as well as the other two dwarf scrub types were part of two other mapping units that are mosaics of two or more types: (1) Heath Dwarf Scrub and Spruce Woodland. This is a mosaic of type 9 (Vaccinium, Ledum Dwarf Scrub) and type 4a (Picea mariana/Vaccinium, Salix Woodland). This type is widespread north of the Kobuk on flat, poorly drained valley lowlands. (2) Dwarf Scrub Fellfield and Carex bigelowii Meadows and Barrens with low plant cover is a complex of alpine tundra vegetation types on upper mountain slopes, ridges, and peaks above alder scrubland at about 600 m. The mobile, unstable sand dune surface can also be assigned to this unit. This mapping unit includes type 10 (Dryas, Lichen Dwarf Scrub) and type 11 (Betula nana Dwarf Scrub) in addition to other types described below.

IV. Herb Types.

Herb types are distinguished from other types by the prevalence of herbaceous perennial plants having a graminoid growth form. Dwarf shrubs may be present as an understory below the uppermost parts of the sedges and grasses.

12. Sedge Tussock Herb Type.

The most widespread herb type, covering up to 10% of the study area, is dominated by tussocks of cottongrass, Eriophorum vaginatum, or Carex bigelowii with associated dwarf shrubs of Ledum palustre, Vaccinium uliginosum, V. vitis-idaea, Betula nana, mosses, and lichens (Fig. 33). The tussocks are frequently of low vigor and in places, they appear to have been invaded or covered with dwarf shrubs. Scattered black spruce sometimes occurs in this type and in one stand (#15), lichen cover was 40%.

The sedge tussock type is particularly important in the Kobuk valley lowlands on the east side of the study area. Beginning east of the Kaliguricheark River (Fig. 7), it covers the flat valley floor on the north side of the Kobuk River. In places it extends northward up tributary valley bottoms into the Baird Mountains. South of the Kobuk there is a broad expanse of sedge tussock type extending from the river, opposite the Hunt River, to the Waring Mountains. The surficial deposits underlying this expanse of sedge tussock vegetation next to the dune fields is mapped by Fernald (1964) as fine textured terrace and fan alluvium. Although polygonal patterns are weakly developed throughout, frost scars were evident near the Akillik River (stand #16; Fig. 33).

Figure 33. Sedge Tussock Herb Type (stand #16) on the flat Kobuk valley floor near the Akillik River (line of dark spruce in background).

13. Carex rostrata Fen.

This herb type is locally important where Kobuk River meanders have developed into alternating strips of dark spruce forest and light green meadows or oxbow lakes. These meander areas occupy about 2% of the study area and occur mainly on the south side of the river (Figs. 3 and 6). Some of these meander strips are covered with herbaceous meadows which probably represent advanced stages of succession in old river channels. Carex rostrata is the most characteristic plant in these meadows called fens because although wet, the substrate is mineral soil or sediment rather than peat or Sphagnum moss (Fig. 34). These fens represent a successional stage in the colonization of old river channels. Part of this successional sequence is reflected in the horizontal zonation of herbs from the wet middle to the drier periphery of these fens. Hippurus vulgaris is sometimes dominant where there is standing water. It is replaced by Equisetum fluviatile where the water is shallower. Carex rostrata then replaces Equisetum fluviatile to form a broad band only broken near the edge of the fen by patches of Calamagrostis canadensis on dry ground (Fig. 34). The zonation sequence from the middle to the edge of a fen is Hippurus vulgaris-Equisetum fluviatile-Carex rostrata-Calamagrostis canadensis. The fen is sharply bounded by p ipheral band of willow scrub, 1.8-2.7 m tall (Fig. 35) usually dominated by Salix planifolia ssp. pulchra or, less often, by S. glauca, S. lanata, or S. alaxensis. Older fens dominated by Carex rostrata and/or Calamagrostis canadensis lack the early herbaceous zones. Beneath the tall graminoids, forbs such as Phleum pratense, Galium Brandegei. G. trifidum, Ranunculus reptans, Barbarea orthoceras, and Epilobium davuricum were found.

There is abundant evidence that moose utilize these fens (Fig. 35). They browse on willows around the edges and bed in or graze on the graminoids. Young (1974) did not describe any vegetation in the Noatak similar to the sedge fen in the Kobuk, however Drury (1956) describes the very limited occurrence of such fens in the Kuskokwim River valley and Johnson and Vogel (1966) found marshy fen to be better developed than sphagnum peats in the Yukon Flats region.

14. Calamagrostis Forb Type.

In places along the banks of the Kobuk River where occasional flooding occurs and deposits of sandy silts accumulate, we found herb types, dominated by the grass Calamagrostis canadensis and forbs such as Parnassia palustris, Aster sibiricus, Chrysanthemum bipinnatum, Allium schoenoprasum, Galium boreale, Equisetum spp., and Sanguisorba officinalis. On gravel bars graminoid plant cover was reduced, but herbs such as Hedysarum alpinum, Astragalus polaris, Artemisia Tilesii, Lupinus arcticus, Galium boreale, and Aster sibiricus were common.

15. Carex aquatilis Herb Type.

Low, wet areas sometimes support wet meadows dominated by Carex

Figure 34. Sedge fen on an old Kobuk River oxbow channel. Graminoid in foreground is Calamagrostis canadensis with Carex rostrata in background.

Figure 35. Bull moose on the edge of a fen with Carex rostrata toward the middle (right) replaced by Calamagrostis canadensis and willows along the edge.

aquatilis. Low shrubs such as Andromeda polifolia, Vaccinium uliginosum, and Salix arctica growing on Sphagnum mounds are often present in these Carex aquatilis meadows. Bog meadows of Carex aquatilis contain species characteristic of bogs in interior Alaska such as Menyanthes trifoliata, Iris setosa, Chamaedaphne calyculata, Triglochin maritimum, Drosera anglica, and Utricularia ssp. We found such bogs only in low-lying inter-dune areas at the Hunt River Dunes (Fig. 2). Wet meadows dominated by Eriophorum angustifolium were found only occasionally near pond margins. On the wet sandy flats by Ahnewetut Creek, where it passes through the Kobuk dunes, Eriophorum scheuchzeri formed wet meadows.

16. Carex bigelowii Herb Type.

Mesic alpine meadows dominated by Carex bigelowii, are of restricted occurrence in the Baird and Waring Mountains. One stand of this type, at 400 m near the crest of the Waring Mountains above the Great Kobuk Sand Dunes, occurred on a flat, poorly drained area. In addition to Carex bigelowii, dwarf shrubs such as Betula nana, Vaccinium uliginosum, Empetrum nigrum, and Ledum palustre were important. In general, however, the alpine conditions which produce suitable habitats for Carex bigelowii meadows are rare; snow beds and seepage areas which serve as a source of moisture are uncommon. Solifluction lobes with which these meadows are often associated are poorly developed except in a few alpine valleys on the upper Hunt and Akillik Rivers (cf. Figs. 15 and 25).

Map Units

Of the herb types, only type 12 (Sedge Tussock Herb Type) is mapped as a relatively homogenous unit called 'Tussock Tundra' on the vegetation map (Fig. 7). Type 12 is also part of a mosaic map unit with Spruce Woodland (type 4a; Picea mariana/Vaccinium, Ledum). These form a mosaic with open black spruce woodland forming a matrix in which there are large patches of tussock tundra. This mosaic occurs mainly on the south side of the Kobuk on flat, poorly drained areas. Type 13 (Carex rostrata Fen) is mapped as part of a vegetation mosaic which results from the floodplain meandering of the Kobuk River. The complexity of the vegetation pattern can be seen in Figure 6 and includes types 3a (Picea glauca/Salix, Alnus), type 3b (Picea glauca/moss), type 6 (Feltleaf Willow Scrub), type 7 (Greenleaf Willow Scrub), and type 2 (Populus balsamifera Forest). Type 16 (Carex bigelowii Meadow) is mapped as part of a complex of alpine vegetation in the Baird and Waring Mountains.

V. Barrens

Where plant cover is less than 10% on upper mountain slopes, ridges, and summits, on gravel bars, and on the mobile sand dunes, a barrens type can be recognized. On the sand dunes, grasses such as Elymus

arenarius, Bromus pumpellianus, or Festuca rubra make up the sparse vegetative cover (see Dune section). On Baird mountain peaks (Fig. 15), plants of rock crevices include Selaginella sibirica, Dryopteris fragrans, Saxifraga bronchialis, Draba spp., Bupleurum triradiatum, Artemisia arctica, Festuca rubra, Epilobium latifolium, Minuartia arctica, Potentilla uniflora, Arnica spp., Erysimum Pallasii, and Linnea borealis. Gravel bars along the Kobuk River and the larger northern tributaries are often barren except for a few herbs such as Hedysarum alpinum, Astragalus polaris (at higher elevations), Artemisia Tilesii, Lupinus arcticus, Galium boreale, Agropyron violaceum, Aster sibiricus, and shrubs such as Shepherdia canadensis and Rosa acicularis.

Map Units

Type V (Barrens) is mapped (Fig. 7) as an important component of the mosaic of alpine tundra vegetation on upper mountain slopes, ridges, and peaks above alder scrubland (Fig. 24). Since much of the Baird Mountains is dry, rocky, and contains extensive limestone barrens, this is the most extensive type, covering about 44% of the area.

VI. Aquatic Types

Submerged and floating aquatic plants are most often associated with ponds and slow moving streams just south of the Kobuk River. Aquatic vegetation is well developed in ponds located in the vicinity of the Great Kobuk Sand Dunes near Kavet and Ahnewetut Creeks and in oxbow lakes associated with old river meanders. The vegetation varies greatly from pond to pond and with water depth. Ponds sometimes have several zones that can be recognized from the edge of the pond out toward the middle. Shoreline species include Carex aquatilis, Potentilla palustris, Menyanthes trifoliata, and Chamaedaphne calyculata, or Salix spp., Carex rostrata and Equisetum fluviatile sometimes form a series of discrete zones. In some ponds, there is a ring of yellow pond lily (Nuphar polysepalum), an aquatic type absent in the Noatak (Young, 1974). Progressing toward slightly deeper water, pond lilies are replaced by submerged species such as Potamogeton spp. (P. perfoliatus, P. gramineus, P. foliosus), Callitriche hermaphroditica, Chara spp., and Myriophyllum spicatum. On slow moving, shallow streams entering the Kobuk from the south, such species as Sparganium hyperboreum and Ranunculus Pallasii are common.

PRIMARY PRODUCTION AND TREE GROWTH

Kobuk vegetation types contain many species that are utilized by local residents and by wildlife as sources of food. In order to provide a better basis for determining the amount of plant food that could be available and the rates at which the different vegetation types capture solar energy, some literature-based estimates of net primary production and biomass are provided in Table 5.

Table 5. Literature-based estimates of biomass and net annual primary production for some vegetation types in the Kobuk National Monument area. A = aboveground; B = belowground estimates.

Vegetation Type This Study	Vegetation Type Source Study	Location	Biomass gms/m^2	Age Years	Net Primary Production gms/m^2/year	Literature Source
Tussock Herb	Tussock Tundra	Yukon Territory	399 A		110-169 AB	Wein and Bliss, 1974
Sedge Fen	Sedge Wetland	Minnesota			738 AB	Bernard, 1974
Sedge Fen	Sedge Oxbows	Alberta			325 A	VanderValk and Bliss, 1971
Several Types	Various Types of Low Arctic Tundra	Low Arctic			40-110 A	Bliss *et al.*, 1973
Picea glauca Forest	*Picea glauca*	Yukon Flats, Ak.	5,099 A	84	73 A	Johnson and Vogel, 1966
Betula papyrifera Forest	*B. papyrifera* Forest	Yukon Flats, Ak.	4,822 A	45	102 A	Johnson and Vogel, 1966
Picea mariana Woodland	*Picea mariana*	Yukon Flats	2,949 A	108	31 A	Johnson and Vogel, 1966
Picea mariana Woodland	*Picea mariana* (lowland)	Fairbanks, Ak.	14,230 A	51	279 A	Barney and VanCleve, 1973
Picea mariana Woodland	*Picea mariana* (upland)	Fairbanks, Ak.	12,760 A	55	232 A	Barney and VanCleve, 1973
Lichen Woodland	Upland Lichen Forest	N. Canada	88 (forage)	75-120		Scotter, 1971
Dwarf Scrub *Dryas*, Lichens	Alpine Tundra	Yukon Flats	3,720 A			Johnson and Vogel, 1966
Alnus crispa Scrub	*Alnus crispa*	Yukon Flats	4,161 A	28	149	Johnson and Vogel, 1966
	Alnus incana	Tanana River Bar	9,469 AB	20	473	VanCleve *et al.*, 1971

Such estimates of biomass and production for a vegetation type are of little value in determining how much of a given resource is available to animals at a particular place in time. First, only a limited fraction or portion of the total biomass or primary production can be utilized. For example, the young willow shoots that can be browsed by moose may account for only 2 to 4% of the net primary production and less than 10% of the biomass of a willow thicket (Van Cleve, Viereck and Schlentner, 1971) or the edible berries of _Vaccinium uliginosum_ which constitute a small fraction of this shrub's biomass which in turn represents only a fraction of the tussock tundra community's biomass. Secondly, annual production and biomass estimates do not indicate at what time of the year a utilizable fraction is available. Both berries and seeds are examples of seasonal resources. Finally, biomass and productivity estimates alone tell us little about the geographical distribution of certain food sources in the study area. The vegetation map provides some idea of the distribution of certain vegetation types for which biomass and production estimates are given. Areas where lichens are abundant for winter forage of caribou are mapped as lichen woodlands. However, for most species used by residents or wildlife the vegetation map is not very useful. _Rubus chamaemorus_ which produces the edible salmon- or cloudberry, is a common species in tussock tundra near the town of Ambler on the Kobuk River. However, it very seldom produces fruit here and residents may travel downriver or to Selawik near the coast to gather fruit. Large paper birch (_Betula papyrifera_) from which residents obtain the bark for baskets, is found only in limited areas generally upriver from the study area.

Many of the productivity and biomass estimates in Table 5 are taken from the high arctic or interior Alaska and are probably not applicable to the Kobuk vegetation. Conspicuously absent from the literature are estimates of primary production for willow scrub vegetation which is often an important browsing habitat for moose in the Kobuk (Fig. 35). The values in Table 5 are presented merely as a basis for later comparisons with actual field determinations of biomass and productivity made in the Kobuk area.

Production and yield of trees in forest stands can be estimated using yield tables based on age-size relationships of trees converted to site indices. Such tables have been developed for white spruce stands (Farr, 1967) and for aspen and birch stands (Gregory and Haack, 1965) in interior Alaska. In the present study we cored trees and counted rings of saplings to determine growth rates (Table 6). When Farr's site index (height of the tallest tree on a 1/4 acre plot at index age 100 years') equations are applied to Kobuk white spruce, it is clear that these trees are growing at very slow rates in comparison with interior white spruce. Although variation in growth from tree to tree is great, the site index values for Kobuk white spruce is generally too low to use Farr's yield tables for interior white spruce. These results generally correspond with the measurements of tree growth by Giddings (1941) along the Kobuk River.

Table 6. Size measurements, age, annual basal area increments, and site index for trees growing in the proposed Kobuk Valley National Monument area, Kobuk River valley, Alaska.

Stand or Location (cf. Table 4)	Altitude (m)	DBH (cm)	Species: Height (m)	Species: Age (yrs)	Annual Basal Area Increment (cm^2)	Farr's Site Index*
			Picea glauca			
No. 1	23	13.5	10.7	190	.77	27
No. 2	183	23.6	12.2	266	1.68	27
No. 2	183	15.7	7.6	54	3.61	36
No. 3	61	39.6	17.1	100	12.32	56
No. 4	46	32.0	18.3	123	6.52	54
No. 5	60	35.6	17.4	252	3.94	40
No. 5	60	21.1	11.3	135	2.58	--
No. 6	64	15.7	8.2	59	3.29	35
No. 7	28	13.2	9.8	60	2.26	43
No. 8	27	15.2	10.7	120	1.55	32
Anaktok Creek	270	20.6	9.1	104	3.23	29
Anaktok Creek	200	13.5	4.9	100	1.42	16
Salmon River	180	25.4	12.2	136	3.74	35
"Oca" Lake	290	30.5	18.3	115	6.32	56
Kallarichuk River	35	47.0	--	114	--	--
Waring Mountains	--	8.8	3.4	59	1.03	15
		Picea glauca: poles and saplings				
Great Kobuk Dunes (Lichen Woodland)		3.8	.96	45		
Great Kobuk Dunes (Lichen Woodland)		1.3	.46	20		
Upper Salmon River	180	1.3	.75	28		
Anaktok Creek	200		1.37	46		
Upper Salmon River	180	1.78	.75	40		
"Oca" Lake	335	1.91	.74	38		
"Oca" Lake	300	1.59	1.17	25		
Kobuk River (Lichen Woodland)		--	.95	56		
Hunt River Dunes		--	1.37	35		
Kobuk River (Lichen Woodland)		7.6	--	56		
			Populus balsamifera			
Salmon River		31.0	15.2	94		
Salmon River		22.3	14.6	88		
Salmon River		17.8	9.1	78		
Salmon River		16.3	8.5	83		
			Betula papyrifera			
No. 7	28	17.3	7.0	70		
Akillik		14.0	10.4	73		
"Oca" Lake		24.4	11.6	72		
Lichen Woodland		6.9	3.1	59		
Lichen Woodland		11.4	--	60		
			Picea mariana			
No. 2	183	14.5	6.1	193		
No. 8	27	10.2	8.2	94		
Old Burn (Salmon River)		10.2	4.6	29		

*Site Index computed from $S = H(0.49638 + 50.36166/A)$ for white spruce: from Farr (1967).

FLORA AND VEGETATION OF THE GREAT KOBUK SAND DUNES

Because the Great Kobuk Sand Dunes represent an unusual and fascinating feature of the proposed Kobuk Valley National Monument, a description of the flora and vegetation is presented separately. Earlier reference was made to the presence of an edemic plant species, Oxytropis kobukensis (Fig. 4), and the ecotypic differentiation that has probably taken place in a number of other species on these dunes. Here, I describe the physiography of the dunes, present a list of the dune flora and describe some of the vegetation types in relation to dune stabilization.

Three active dunefield areas lie within or near the boundary of the proposed Kobuk Valley National Monument (Fig. 36): the Great Kobuk Sand Dunes covering about 56 km^2; the Hunt River Dunes (Fig. 3) bordering the Kobuk River opposite the mouth of the Hunt River occupying about 5 km^2; and the Little Kobuk Sand Dunes, covering 22 km^2, just east of the study area. These sparsely vegetated areas of mobile sand represent only about 10% of a 780 km^2 area occupied by two large, mostly stablized and vegetated dunefields (Fernald, 1964).

In Alaska, sand dunes are found in scattered localities along the coast and in the interior. On the coast, sand dunes occur along the shores of the Gulf of Alaska, the Aleutian Islands, the Bering Sea, the Bering Sea islands, and the Seward Peninsula (Black, 1951). In addition, there are dune fields in the Arctic Coastal Plain, along the lower portions of large rivers such as the Colville and Meade Rivers. Interior sand dunes occur in central Alaska near the Yukon and Kuskokwim Rivers. Many of these dune fields, such as the Kuskokwim Mountain Dunes, are stabilized and vegetated with aspen or birch (Collins, 1958). Another large dune area, the Nagabahara Dunes, is located about 160 km southeast of the Great Kobuk Sand Dunes. Maritime Coastal Dunes are located about 240 km west of the Kobuk Dunes at Cape Espenberg on the Seward Peninsula.

The Great Kobuk Sand Dunes lie in the southwest corner of a large dune field (Fig. 36). The northeastern half of the dune field is stabilized and vegetated with lichen woodland. Along the northeastern edge of the active dune area there is a nearly continuous transition from open, mobile sand to stabilized, lichen woodland. Our successional studies were conducted within this transition zone. To the south and west, the dunes are now and have in the past buried spruce forest (Fig. 37). The surfaces of the vegetation-free dunes on the east are undulating and marked by a few transverse north-south running ridges (Figs. 37 and 38). To the west, dunes become 40 m high and U-shaped with long arms oriented toward the west. Although Fernald (1964) has called these dunes barchans, they are most likely modified transverse dunes (Florence Weber, U.S.G.S., Fairbanks, Alaska, pers. comm.).

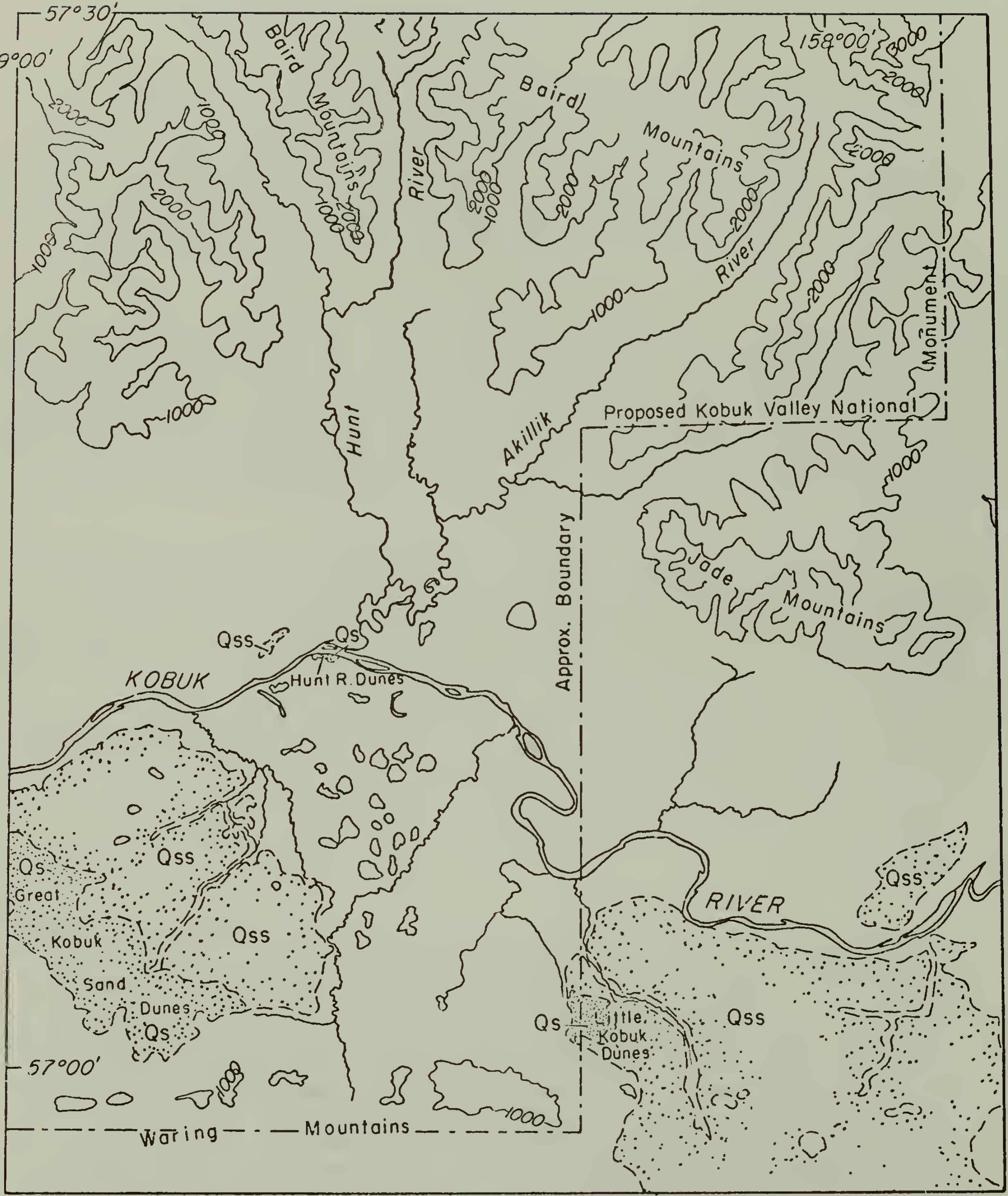

Figure 36. Location of dune fields that lie mainly south of the Kobuk River. Qs denotes areas of unstable, mobile sand; Qss indicates stabilized (vegetated) sand areas. After Fernald (1964).

Figure 37. Southwest edge of the Great Kobuk Sand Dunes along Kavet Creek. Line of spruce on right is adjacent to Ahnewetut Creek.

Figure 38. Ahnewetut Creek flowing northwest through the Great Kobuk Sand Dunes. The sparsely vegetated dunes lie along the east edge of the creek; the heavily vegetated area is on the west side, but only as a narrow strip. Further west sparsely vegetated dunes occur.

Fernald attributes these dunes to both present and past easterly winds. It is not known why the Great Kobuk Sand Dunes remained unstabilized by vegetation following glaciation and the return of more favorable conditions for plant growth. The Hunt River Dunes (Fig. 3) appear to be maintained by the strong winds that the local residents say sweep southward down the Hunt-Akillik River valleys.

FLORA

A list of vascular plant species collected at the Great Kobuk and Hunt River Sand Dunes is presented in Appendix II. Several aspects of the dune flora are discussed above under 'Habitats of Special Interest' and 'Phytogeographical Relationships'.

VEGETATION

An attempt was made to find an area where all stages of sand dune succession or stabilization could be observed and sampled. Along the northeastern edge of the Great Kobuk Sand Dunes, near Ahnewetut Creek, there is a nearly continuous transition from bare, mobile sand to stabilized, vegetated sand flats where there appears to be little deposition or removal of sand. Most of the following descriptions are based on observations or sampling in this area.

The crests and slopes of dunes (Fig. 39) are usually active surfaces with a sparse plant cover of less than 1%. Species in this habitat include Bromus pumpellianus, Chrysanthemum bipinnatum, and Elymus arenarius. Other species which occur locally on open windswept sand surfaces include Artemisia borealis, Astragalus alpinus, Oxytropis viscida, Oxytropis kobukensis, Senecio conterminus, Lupinus arcticus, Parrya nudicaulis, Anemone Drummondii, Lesquerella arctica, Epilobium latifolium, and Minuartia arctica. In places on these unstable surfaces one finds low Salix alaxensis (Fig. 40), S. glauca, or Populus balsamifera the bases of which often appear to be buried by sand. Populus balsamifera also occurs where sand is being eroded leaving roots suspended in air.

Stabilization begins on fairly flat surfaces with the development of regularly spaced, robust clumps of grasses such as Festuca rubra and/or Elymus arenarius (Fig. 41). Plant cover at this stage is less than 10% and on the mound of sand trapped at the base of these grasses one can find such forbs as Anemone Drummondii, Oxytropis viscida, Eritrichium splendens, Oxytropis kobukensis, Cnidium cnidiifolium, and Artemisia borealis (Fig. 41).

The next successional stage is marked by the colonization of the sand surface by lichen species such as Evernia perfragilis and Stereocaulon spp. and the death and decline of the grasses in the preceding stage (Fig. 42). At this stage there is about 40% plant cover and species characteristic of this stage include Kobresia myosuroides,

Figure 39. Base of dune on the Great Kobuk Sand Dunes. Grass on slope is Bromus pumpellianus.

Figure 40. Shoot tips of *Salix alaxensis* being covered by shifting sands on the Great Kobuk Sand Dunes.

Figure 41. Anemone Drummondii growing on sand mound at the base of Festuca rubra.

Figure 42. Early successional stage along the edge of the Great Kobuk Sand Dunes (see Column 1 of Table 7).

Zygadenus elegans, Plantago canescens, Dianthus repens, and Bupleurum triradiatum (Table 7).

Succession then proceeds with an increase in lichen cover and the appearance of such dwarf shrub species as Silene acaulis and Dryas integrifolia (Figs. 43 and 44). The lichens, Cornicularia divergens, Evernia perfragilis, and Cetraria nivalis exhibit increased cover compared with the earlier stage and occur together with such herbs as Minuartia Rossii, Erigeron purpuratus, and Androsace chamaejasme to produce a total cover of about 60% of the sand surface (Table 7).

Plant cover increases to 80-90% with the development of such prostrate shrubs as Arctostaphylos uva-ursi, A. alpina, Saxifraga oppositifolia, and Dryas integrifolia. Fruticose lichen species such as Cladonia alpestris and Cladina rangiferina also increase to form a fairly rich lichen-dwarf shrub community. White spruce invasion may also occur at this stage leading to the development of lichen woodland.

Some other localized vegetation types and habitats deserve mention. On wet sand, where water seeps from beneath the base of a dune blowout, low willows are present and the wet flatland is covered with Eleocharis palustris, Juncus castaneus, and Calamagrostis neglecta. Where the inside floor of a U-shaped dune is dry, there is often a well vegetated flat of Dryas integrifolia, Arctostaphylos alpina, Equisetum scirpoides, Minuartia Rossii, Aster sibiricus, and patches of Salix glauca, S. alaxensis, and Shepherdia canadensis. On some raised, windswept areas there is a hard and encrusted sand surface without any plants.

ACKNOWLEDGMENTS

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Table 7. Average cover values for species at two stages of succession or stabilization on sand dune surfaces of the Great Kobuk Sand Dunes.

	Cover (%) in Stands With:	
	40% Plant Total Cover (Fig. 41)	60% Plant Total Cover (Figs. 42 and 43)
Graminoids		
Kobresia myosuroides	9.6	3.6
Festuca rubra	9.0	6.4
Bromus pumpellianus	.8	0.0
Forbs		
Anemone Drummondii	1.2	0.0
Minuartia arctica	4.0	0.0
Astragalus alpinus	1.6	0.0
Cnidium cnidiifolium	2.2	0.0
Senecio residifolius	.6	0.0
Zygadenus elegans	.6	0.0
Oxytropis kobukensis	2.6	0.0
Bupleurum triradiatum	2.4	-
Eretrichium splendens	1.0	-
Artemisia borealis	2.4	2.0
Minuartia Rossii	-	6.2
Oxytropis viscida	0.0	1.0
Plantago canescens	.8	1.0
Silene acaulis	0.0	8.2
Erigeron purpuratus	0.0	3.4
Androsace chamaejasme	0.0	4.4
Pedicularis spp.	0.0	-
Lichens		
Evernia perfragilis	1.4	2.0
Cornicularia divergens	1.0	9.6
Stereocaulon spp.	-	.4
Thamnolia vermicularis	1.0	7.6
Cetraria nivalis	0.0	2.8

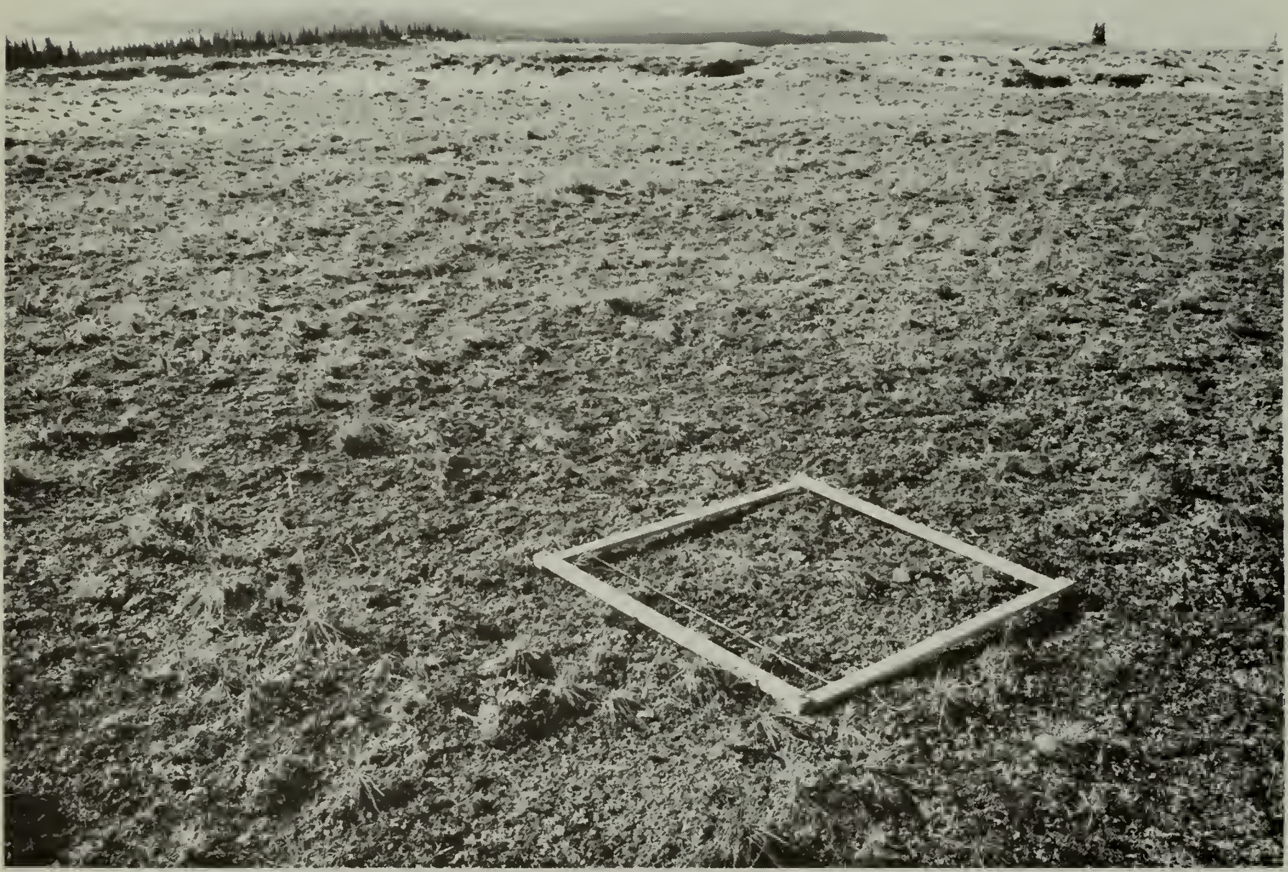

Figure 43. Area near edge of Great Kobuk Sand Dunes being stabilized by lichens. Quadrat is 1 m x 1 m.

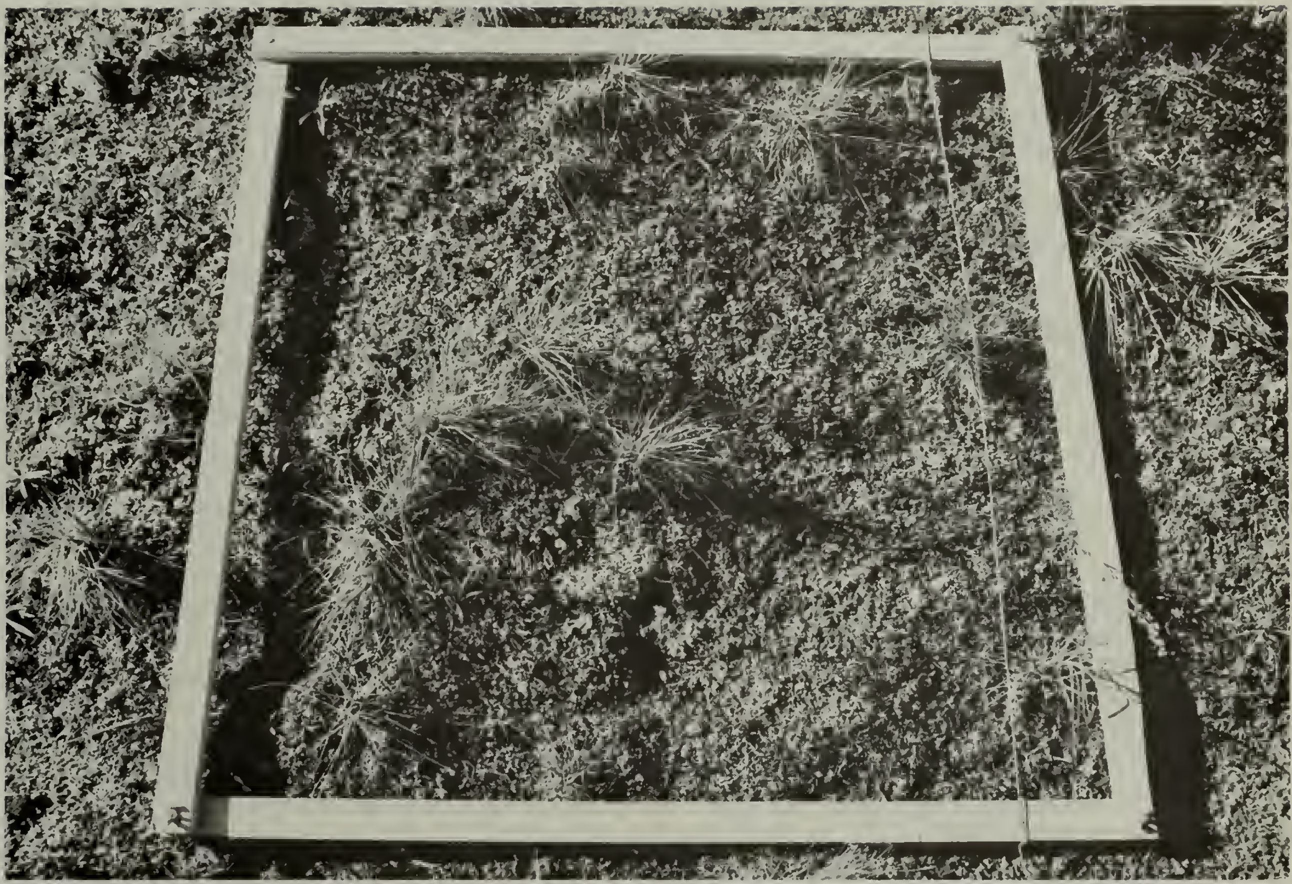

Figure 44. Later successional stage along the edge of the Great Kobuk Sand Dunes (cf. Table 7). Quadrat is 1 m x 1 m.

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Appendix I. Vascular flora of the Kobuk study area based on collections and sight observations. Nomenclature follows Hulten (1968); range extensions based on Hulten's maps; absence from the Noatak River basin based on Young (1974).

LYCOPODIACEAE

Lycopodium selago L.	
Lycopodium annotinum L.	
Lycopodium clavatum L.	
Lycopodium complanatum L.	extends range westward, not in Noatak
Lycopodium alpinum L.	not in Noatak

SELAGINELLACEAE

Selaginella sibirica (Milde) Hieron.	rocky montane areas

EQUISETACEAE

Equisetum variegatum Schleich.	
Equisetum scirpoides Michx.	
Equisetum fluviatile L. ampl. Ehrh.	
Equisetum silvaticum L.	not in the Noatak
Equisetum pratense L.	not in the Noatak
Equisetum arvense L.	

CRYPTOGRAMMACEAE

Cryptogramma Stelleri (S. G. Gmel.) Prantl.	extends range

ASPLENIACEAE

Asplenium viride Huds.	not in the Noatak

ATHYRIACEAE

Cystopteris fragilis (L.) Bernh.

Woodsia ilvensis (L.) R. Br.

Woodsia alpina (Bolton) S. F. Gray

Appendix I. Continued.

ASPIDIACEAE

Dryopteris fragrans (L.) Schott

PINACEAE

Picea glauca (Moench) Voss

Picea mariana (Mill.) Britt., Sterns and Pogg.

CUPRESSACEAE

Juniperus communis L.

SPARGANIACEAE

Sparganium hyperboreum Laest.

POTAMOGETONACEAE

Potamogeton alpinus Balb.

Potamogeton gramineus L.

Potamogeton perfoliatus L.

Potamogeton zosterifolius Schum.

Potamogeton Friesii Rupr.

Potamogeton foliosus Raf.

Potamogeton pectinatus L.

Potamogeton filiformis Pers.

JUNCAGINACEAE

Triglochin maritimum L.

Triglochin palustris L.

GRAMINEAE

Hierochloë alpina (Sw.) Roem. and Schult.

Phleum pratense L.	extends range northward, not found in Noatak
Agrostis scabra Willd.	extends range northwestward, not in Noatak

Appendix I. Continued.

Calamagrostis canadensis (Michx.) Beauv.
Calamagrostis neglecta (Ehrh.) Gaertn., Mey. and Schreb.
Deschampsia caespitosa (L.) Beauv.
Tristetum spicatum (L.) Richter
Beckmannia erucaeformis (L.) Host
Poa glauca M. Vahl
Festuca rubra L.
Bromus Pumpellianus Scribn.
Agropyron violaceum (Hornem.) Lange
Elymus arenarius L.

CYPERACEAE

Eriophorum angustifolium Honck.
Eriophorum Scheuchzeri Hoppe
Eriophorum vaginatum L.
Eleocharis palustris (L.) Roem. and Schult. extends range westward
Eleocharis acicularis (L.) Roem. and Schult.
Kobresia myosuroides (Vill.) Fiori and Paol.
Carex scirpoidea Michx.
Carex canescens L. extends range westward
Carex Bigelowii Torr.
Carex aquatilis Wahlenb.
Carex podocarpa C. B. Clarke
Carex microchaeta Holm
Carex limosa L.
Carex Oederi Retz.
Carex rostrata Stokes
Carex rotundata Wahlenb.
Carex membranacea Hook.

JUNCACEAE

Juncus castaneus Sm.

Appendix I. Continued.

Juncus alpinus Vill.	extends range westward, not in Noatak
Juncus triglumis L.	
LILIACEAE	
Tofieldia coccinea Richards.	
Tofieldia pusilla (Michx.) Pers.	
Zygadenus elegans Pursh	
Allium schoenoprasum L.	
Lloydia serotina (L.) Rchb.	
IRIDACEAE	
Iris setosa Pall.	
ORCHIDACEAE	
Cypripedium passerinum Richards.	
Amerorchis rotundifolia (Banks) Hult.	
Platanthera hyperborea (L.) Lindl.	extends range westward, not in Noatak
Platanthera obtusata (Pursh) Lindl.	
Spiranthes Romanzoffiana Cham.	extends range westward, not in Noatak
Goodyera repens (L.) R. Br.	extends range northwestward, not in Noatak
SALICACEAE	
Populus balsamifera L.	
Populus tremuloides Michx.	not in Noatak, extends range westward
Salix reticulata L.	
Salix phlebophylla Anderss.	
Salix arctica Pall.	
Salix brachycarpa ssp. *niphoclada* (Rydb.) Argus	
Salix glauca L.	
Salix fuscescens Anderss.	

Appendix I. Continued.

Salix fuscescens Anderss.
Salix hastata L.
Salix planifolia ssp. *pulchra* (Cham.) Argus
Salix arbusculoides Anderss.
Salix lanata ssp. *richardsonii* (Hook.) A. Skv.
Salix alaxensis (Anderss.) Cov.

MYRICACEAE

Myrica gale L. — extends range to west, not in Noatak

BETULACEAE

Betula nana L.
Betula glandulosa Michx.
Betula papyrifera Marsh. — extends range westward
Alnus crispa (Ait.) Pursh — both ssp. *sinuata* and ssp. *crispa*.

SANTALACEAE

Geocaulon lividum (Richards.) Fern. — extends range westward, not in Noatak

POLYGONACEAE

Rumex arcticus Trautv.
Oxyria digyna (L.) Hill
Polygonum viviparum L.
Polygonum bistorta L.
Polygonum alaskanum (Small) Wight — not in Noatak

CHENOPODIACEAE

Corispermum hyssopifolium L. — extends range westward, not in Noatak

PORTULACACEAE

Claytonia sarmentosa C. A. Mey.

Appendix I. Continued.

Montia fontana L.	extends range eastward
CARYOPHYLLACEAE	
Stellaria monantha Hult.	
Cerastium Beeringianum Cham. and Schlecht.	
Cerastium jenisejense Hult.	
Minuartia arctica (Stev.) Aschers. and Graebn.	
Minuartia Rossii (R. Br.) Graebn.	
Moehringia lateriflora (L.) Fenzl	
Wilhelmsia physodes (Fisch.) McNeill	
Silene acaulis L.	
Melandrium Taylorae (Robins.) Tolm.	
Dianthus repens Willd.	
NYMPHAEACEAE	
Nuphar polysepalum Engelm.	not in Noatak
RANUNCULACEAE	
Caltha palustris L.	
Delphinium brachycentrum Ledeb.	
Delphinium glaucum S. Wats.	extends range westward, not in Noatak
Aconitum delphinifolium DC.	
Anemone Richardsonii Hook.	
Anemone narcissiflora L.	
Anemone Drummondii S. Wats.	
Ranunculus Gmelini DC.	extends range westward
Ranunculus Pallasii Schlecht.	extends range eastward
Ranunculus reptans L.	not in Noatak
Thalictrum alpinum L.	extends range southward
Thalictrum sparsiflorum Turcz.	extends range northwestward

Appendix I. Continued.

PAPAVERACEAE

Papaver Walpolei Pors. extends range eastward
Papaver Macounii Greene
Papaver lapponicum (Tolm.) Nordh.
Papaver nudicaule L.
Corydalis pauciflora (Steph.) Pers.

CRUCIFERAE

Roripa islandica (Oeder) Borb. not in Noatak
Cardamine pratensis L.
Cardamine microphylla Adams
Lesquerella arctica (Wormsk.) S. Wats.
Draba palanderiana Kjellm.
Descurainia sophioides (Fisch.) O. E. Schulz
Arabis arenicola (Richards.) Gelert extends range southeastward
Erysimum Pallasii (Pursh) Fern.
Braya humilis (C. A. Mey.) Robins.
Parrya nudicaulis (L.) Regel

DROSERACEAE

Drosera anglica Huds. extends range northward

CRASSULACEAE

Sedum rosea (L.) Scop.

SAXIFRAGACEAE

Boykinia Richardsonii (Hook.) Gray
Saxifraga oppositifolia L.
Saxifraga hirculis L.
Saxifraga bronchialis L.
Saxifraga tricuspidata Rottb.
Saxifraga spicata D. Don extends range westward

Appendix I. Continued.

Saxifraga hieracifolia Waldst. and Kit.
Chrysosplenium tetrandrum (Lund) T. Fries
Parnassia palustris L.
Parnassia Kotzebuei Cham. and Schlecht.
Ribes triste Pall.

ROSACEAE

Spiraea Beauverdiana Schneid.
Rubus chamaemorus L.
Rubus arcticus L.
Potentilla palustris (L.) Scop.
Potentilla fruticosa L.
Potentilla biflora Willd. — extends range southward
Potentilla uniflora Ledeb.
Potentilla Hookeriana Lehm.
Geum glaciale Adams
Dryas octopetala L.
Dryas integrifolia M. Vahl
Sanguisorba officinalis L.
Rosa acicularis Lindl. — extremely rare in the Noatak

LEGUMINOSAE

Lupinus arcticus S. Wats.
Astragalus aboriginum Richards — extends range southward
Astragalus alpinus L. subsp. *arcticus* (Bunge) Hult. — extends range southward
Astragalus polaris Benth.
Oxytropis Scammaniana Hult. — extends range westward
Oxytropis nigrescens (Pall.) Fisch.
Oxytropis kobukensis Welsh — endemic to the Hunt and Great Kobuk Sand Dunes
Oxytropis koyukukensis Pors. — extends range southwestward

Appendix I. Continued.

Oxytropis viscida Nutt.	extends range westward
Hedysarum alpinum L.	

CALLITRICHACEAE

Callitriche hermaphroditica L.

VIOLACEAE

Viola epipsila Ledeb.

ELEAGNACEAE

Shepherdia canadensis (L.) Nutt.

ONAGRACEAE

Epilobium angustifolium L.
Epilobium latifolium L.
Epilobium palustre L.
Epilobium davuricum Fisch.

HALORAGACEAE

Myriophyllum spicatum L.
Hippuris vulgaris L.

UMBELLIFERAE

Bupleurum triradiatum Adams	
Cicuta mackenzieana Raup	extends range northward, not in Noatak
Cnidium cnidiifolium (Turcz.) Schischk.	
Angelica lucida L.	

CORNACEAE

Cornus suecica L.

Appendix I. Continued.

PYROLACEAE

Pyrola asarifolia Michx.

Pyrola grandiflora Radius

Pyrola secunda L.

Moneses uniflora (L.) Gray — extends range northwestward

EMPETRACEAE

Empetrum nigrum L.

ERICACEAE

Ledum palustre L.

Rhododendron lapponicum (L.) Wahlenb.

Loiseleuria procumbens (L.) Desv.

Cassiope tetragona (L.) D. Don

Andromeda polifolia L.

Chamaedaphne calyculata (L.) Moench

Arctostaphylos uva-ursi (L.) Spreng.

Arctostaphylos alpina (L.) Spreng.

Vaccinium vitis-idaea L.

Vaccinium uliginosum L.

Oxycoccus microcarpus Turcz.

DIAPENSIACEAE

Diapensia lapponica L.

PRIMULACEAE

Primula sibirica Jacq. — not in Noatak

Primula egaliksensis Wormsk.

Androsace chamaejasme Host

Trientalis europaea L. — not in Noatak

Appendix I. Continued.

PLUMBAGINACEAE

Armeria maritima (Mill.) Willd. extends range eastward

GENTIANACEAE

Gentiana glauca Pall.

Gentiana propinqua Richards. extends range southward

Lomatogonium rotatum (L.) E. Fries

Menyanthes trifoliata L.

POLEMONIACEAE

Phlox sibirica L.

Polemonium acutiflorum Willd.

BORAGINACEAE

Eritrichium splendens Kearney

Mertensia paniculata (Ait.) G. Don

SCROPHULARIACEAE

Lagotis glauca Gaertn.

Castilleja caudata (Pennell) Rebr.

Castilleja elegans Malte

Pedicularis verticillata L.

Pedicularis labradorica Wirsing

Pedicularis Langsdorfii Fisch.

Pedicularis sudetica Willd.

Pedicularis capitata Adams

Pedicularis Oederi M. Vahl

OROBANCHACEAE

Boschniakia rossica (Cham. and Schlecht.) Fedtsch.

Appendix I. Continued.

LENTIBULARIACEAE

Pinguicula vulgaris L.
Utricularia vulgaris L.
Utricularia intermedia Hayne
Utricularia minor L. — extends range westward

PLANTAGINACEAE

Plantago canescens Adams — extends range westward, rare in Noatak

RUBIACEAE

Galium boreale L.
Galium trifidum L. — extends range westward
Galium Brandegei Gray

CAPRIFOLIACEAE

Viburnum edule (Michx.) Raf. — extends range westward
Linnaea borealis L.

VALERIANACEAE

Valeriana capitata Pall.

CAMPANULACEAE

Campanula lasiocarpa Cham.
Campanula uniflora L.

COMPOSITAE

Solidago multiradiata Ait.
Aster sibiricus L.
Erigeron hyperboreus Greene
Antennaria monocephala DC.
Antennaria Friesiana (Trautv.) Ekman
Achillea sibirica Ledeb.

Appendix I. Continued.

Matricaria matricarioides (Less.) Porter

Chrysanthemum bipinnatum L.

Chrysanthemum integrifolium Richards.

Artemisia Tilesii Ledeb.

Artemisia arctica Less.

Artemisia borealis Pall.

Petasites frigidus (L.) Franch.

Arnica Lessingii Greene

Senecio congestus (R. Br.) DC.

Senecio atropurpureus (Ledeb.) Fedtsch.

Senecio resedifolius Less. May be the same

Senecio conterminus Greenm.

Senecio lugens Richards.

Saussurea angustifolia (Willd.) DC.

Saussurea viscida Hult.

Taraxacum spp.

Crepis nana Richards.

Appendix II. Preliminary vascular flora of the Great Kobuk Sand Dunes and the Hunt River Sand Dunes. Where a species was found only on the Hunt River Dunes, an (H) follows the name. Dune habitats for each species are specified by: M - mobile, open sand; SS - semistabilized with some lichens; S - stabilized; W - wet, sandy seepage; L - lichen woodland. An asterisk (*) marks species which were found only in the sand dune areas of the proposed Kobuk Valley National Monument.

SELAGINELLACEAE	
Selaginella sibirica	SS
Equisetum variegatum	
Equisetum scirpoides	M
Equisetum arvense	
PINACEAE	
Picea glauca	L
Picea mariana	L
Juniperus communis	SS
JUNCAGINACEAE	
Triglochin maritimum	W
GRAMINEAE	
Agrostis scabra	W
Calamagrostis canadensis	
Calamagrostis neglecta	
Deschampsia caespitosa	
Festuca rubra	M, SS
Bromus Pumpellianus	* M
Elymus arenarius	* M
CYPERACEAE	
Eriophorum Scheuchzeri	W
Eleocharis palustris	W

Appendix II. Continued.

Kobresia myosuroides	* SS
Carex scirpoidea	
Carex Oederi	W
Carex rotundata	W
Carex membranacea	
JUNCACEAE	
Juncus castaneus	W
Juncus alpinus	W
LILIACEAE	
Tofieldia pusilla	SS
Zygadenus elegans	* SS
Allium schoenoprasum	S
IRIDACEAE	
Iris setosa	W
ORCHIDACEAE	
Platanthera hyperborea	S
Goodyera repens	Spruce forest along Ahnewetut Creek
SALICACEAE	
Populus balsamifera	M, S, L
Populus tremuloides	L
Salix reticulata	S
Salix brachycarpa ssp. *niphoclada* (Rydb.) Argus	
Salix glauca	M
Salix alaxensis	M
BETULACEAE	
Betula glandulosa	S

Appendix II. Continued.

POLYGONACEAE	
Polygonum viviparum	S
CHENOPODIACEAE	
Corispermum hyssopifolium	(H), M
CARYOPHYLLACEAE	
Minuartia arctica	* M, SS
Minuartia Rossii	* SS
Silene acaulis	* M, SS
Melandrium Taylorae	(H), M
Dianthus repens	* M
RANUNCULACEAE	
Anemone Drummondii	* M
Thalictrum alpinum	S
PAPAVERACEAE	
Papaver nudicaule	W
CRUCIFERAE	
Lesquerella arctica	* M
Braya humilis ssp. *Richardsonii*	M
Parrya nudicaulis	* M
SAXIFRAGACEAE	
Saxifraga oppositifolia	S
Parnassia palustris	S
ROSACEAE	
Potentilla fruticosa	S

Appendix II. Continued.

Potentilla Hookeriana	
Dryas integrifolia	SS, S
LEGUMINOSEAE	
Lupinus arcticus	M, L
Astragalus aboriginum	
Astragalus alpinus ssp. arcticus	* M
Oxytropis kobukensis	* M
Oxytropis viscida	* M
Hedysarum alpinum	
ELEAGNACEAE	
Shepherdia canadensis	S, L
ONAGRACEAE	
Epilobium latifolium	M
UMBELLIFERAE	
Bupleurum triradiatum	M, SS
Cnidium cnidiifolium	* M, SS
EMPETRACEAE	
Empetrum nigrum	L, S
ERICACEAE	
Rhododendron lapponicum	S
Arctostaphylos uva-ursi	* SS, L
Arctostaphylos alpina	SS, L
Vaccinium vitis-idaea	SS

Appendix II. Continued.

PRIMULACEAE	
Primula egaliksensis	
Androsace chamaejasme	* SS
PLUMBAGINACEAE	
Armeria maritima	SS
GENTIANACEAE	
Gentiana propinqua	(H)
BORAGINACEAE	
Eritrichium splendens	* M, SS
SCROPHULARIACEAE	
Castilleja caudata	S
Pedicularis verticillata	S, W
Pedicularis capitata	S
PLANTAGINACEAE	
Plantago canescens	* M, SS
COMPOSITAE	
Solidago multiradiata	S
Aster sibiricus	M
Erigeron hyperboreus	SS
Chrysanthemum bipinnatum	M
Artemisia Tilesii	
Artemisia borealis	* M
Arnica Lessingii	S
Senecio resedifolius	* M } these two species may hybridize
Senecio conterminus	* M
Saussurea angustifolia	S

PART III

VERTEBRATES OF THE PROPOSED KOBUK VALLEY NATIONAL MONUMENT

by

Herbert R. Melchior, Kenneth R. Whitten,
and Richard T. Schideler

This part of the report reviews the past and present status of amphibions, fish, birds, and mammals that are known to occur within the proposed Kobuk Valley National Monument area, and more broadly, the Kobuk River drainage. Emphasis has been placed on the fish and mammals utilized by residents along the river since there has been a long historical dependence upon certain species of fish and the larger mammals for sustenance and other needs.

Based upon existing literature, there appear to be 155 species of vertebrates residing within the Kobuk River drainage.[1] The breakdown into major groups is as follows: one amphibian, 25 species of fish, 102 species of birds, and 27 species of mammals (see Dean and Chesemore, 1974, and McPail and Lindsey, 1970 for enumeration). Most of these species probably occur within the boundaries of the proposed Kobuk Valley National Monument but there might be a few species, like lake trout (known to occur in Walker Lake at the head of the Kobuk), which do not occur in the proposed KVNM because their rather specialized habitat (in the case of lake trout, relatively large, deep lakes) is not present.

PREVIOUS STUDIES

To date, there has been no complete field survey of any major vertebrate group within the Kobuk River drainage. Early explorers recorded sightings of animals as they worked their way up and down the Kobuk River, but they did not stray far from the main river. The first recorded natural history observations of any substance resulted from the travels of Cantwell (1887, 1889), McLenegan (1889a, 1889b), and Townsend (1887) in the summer of 1884 and 1885. Following their explorations, McLenegan (1889b) reported on 83 species of birds and Townsend (1887) reported on 12 species of fish, 58 species of birds and 16 species of mammals. Joseph Grinnell, who spent the winter of 1889-1900 on the Kobuk near the mouth of the Hunt River with a group of miners, published two works based upon his experience, a general narrative account (Grinnell, 1901), that included natural history observations and a major work on the birds of the Kotzebue

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[1] Resident species are defined here as those that have individuals living year around within the drainage, or if a migratory species, those that have individuals spending an important portion of their annual cycle within the drainage.

region (Grinnell, 1900). The latter included his ornithological observations from the Kobuk River area. Other observations of animal life along the Kobuk were made by geological and topographic survey parties (Mendenhall, 1902; Smith, 1913; Smith and Mertie, 1930).

In 1954 the U.S. Fish and Wildlife Service made a survey of village wildlife utilization (Woolford, n.d.) and in 1957 they made a reconnaissance of salmon fisheries (Raleigh, 1957 as cited in Mattson, 1962). Irving (1960) included observations on birds that he made at the village of Kobuk in his study of the Arctic adaptations of birds.

In the late 1950's and early 1960's, attention was focused on the northwestern Arctic caribou herd. Early enumerative surveys, that were conducted by the U.S. Fish and Wildlife Service (e.g., Olson, 1957, 1958, and 1959), were followed by several studies on specific aspects of caribou ecology (Henshaw, 1964, 1968; Lentfer, 1965; Lent, 1966; Skoog, 1963, 1968). Since statehood in 1959, the Alaska Department of Fish and Game has been carrying out aerial game surveys. Although the Department attempts to conduct some form of aerial survey of the major game species in each region on an annual basis, poor flying weather, budget constraints and other factors have limited most of their earlier efforts to casual surveys rather than carefully controlled, intensive surveys. A census of the western Arctic caribou herd was made in 1970 (Hemming, 1971) and again in 1975 and 1976. The results of these surveys are generally reported in Annual Project Segment Reports, kept on file at the major offices of the Department.

In 1963 a survey of the birds and mammals in the Baird and Schwatka Mountains was carried out be Dean and Chesemore (1974). The areas within the Kobuk Drainage that they studied intensively were located east of the proposed Kobuk Valley National Monument at "Redstone" Lake and Walker Lake.

In 1965-1966, Alt (1969) conducted a study of the inconnu and compiled a list of other species of fish that inhabit the Kobuk River. Since 1962, the Alaska Department of Fish and Game has conducted surveys and compiled statistics on the subsistence and commercial harvest of salmon (primarily chum salmon), dolly varden/Arctic char, and inconnu (sheefish) of the Kotzebue region, and have conducted aerial surveys of chum salmon spawning in the Kobuk River and its major tributaries (ADF&G, 1973).

METHODS

There are many factors that affect the completeness of surveys of vertebrates. The most important of these, which are relevant to our survey of the proposed KVNM, are discussed briefly below. These factors have affected the adequacy of all previous surveys as well as our own and should be kept in mind by the reader as he or she proceeds through the remainder of this account.

An important feature of the Kobuk ecosystem is that certain vertebrates are intermittantly present within the system as a result of migratory movement. Caribou, a host of migratory bird species, and several species of fish, most notably chum salmon, flow through or move into and out of the area each year. Non-migratory species also undergo movements, such as seasonal shifts between habitats, which, although less spectacular than major migrations, nevertheless affect an observer's ability to detect their presence. Variations in conspicuousness and/or capturability also affect the success of surveys. Included here are habitat related factors (e.g., differences in "cover" created by structural differences in tundra versus forest or aquatic versus terrestrial habitats); seasonal related factors (e.g., summer versus winter); and population density and dispersion factors (e.g., solitary species such as wolverine versus gregarious species such as caribou; or pronounced fluctuations between low numbers and high numbers within a species, a feature characteristic of many northern populations of vertebrates).

Field Survey Methods

Field work for the vertebrate survey was carried out in the Kobuk valley during three visits: 15-20 September 1973, 17 July-29 August 1974, and 13-15 March 1975.

Daily, general observations of animals or their sign, the habitats they occupied, and evidence of their utilization of resources were recorded in field notebooks during all travel within the proposed KVNM. Photographic records were made of many species or their sign as time and conditions permitted. Fish were taken by rod and reel using Mepps lures and Daredevils. Captured fish were measured and for some, the stomach contents examined and the reproductive condition noted. Summer-time aerial surveys were flown over major streams during which counts were made of beaver dams and lodges, moose, wolves, and bear. A separate aerial survey was made over the Baird Mountains to count Dall sheep and evaluate alpine sheep range. Another aerial survey was made to delineate the boundaries of major vegetation/habitat types; oblique, 35 mm color transparencies were taken of representative areas of the major types. Snap trapping for small mammals in selected locations was carried out and specimens of red squirrel and porcupine were collected by gun during a short visit to the area between 15 and 20 September 1973. Between the 13 and 15 of March 1975, snow depth and hardness were sampled and aerial surveys were made of the distribution and relative abundance of caribou and moose.

Literature Survey and Personal Contacts

Before preparing this report we reviewed all of the available reports of previous surveys and studies that relate to the Kobuk River region. We also examined unpublished reports and data on file with the Alaska Department of Fish and Game and documents on file in the Wildlife Library at the University of Alaska, Fairbanks. In addition, we informally interviewed and had discussions with residents of Kiana and Ambler,

and state and federal biologists who are familiar with the area. References to these sources are identified in the text where appropriate.

ACCOUNTS OF VERTEBRATE GROUPS AND SPECIES

AMPHIBIANS

One amphibian, the wood frog (Rana sylvatica), occurs within the Kobuk River drainage, including the proposed KVNM. We collected a specimen from the north bank of the Ambler River near its junction with the Kobuk River on 18 July 1974 and we photographed two frogs that we found near the mouth of Ahnewetut Creek on 21 July 1974. A specimen was collected in July 1973 at the mouth of the Salmon River and another one was collected at the Onion Portage Archeological Site by members of a Department of Interior planning team (letter dated December 3, 1974 from J. Reynolds, National Park Service, Denver, Colorado).

An early distribution map (Wright and Wright, 1949) showed the northern limit of the wood frog in Alaska as lying somewhere between the Yukon and Koyukuk rivers or about 225 km southeast of the Kobuk River. Hock (1956) reported the northern limit as extending westward from Fort Yukon through Bettles to Kiana on the Kobuk, but Stebbins (1962) showed a northern limit similar to the one reported by Wright and Wright (1949). The most recent review of the distribution of wood frogs in Alaska (Hodge, in press) shows sites within and on the north side of the central Brooks Range (upper Alatna River, Anaktuvuk Pass, Galbraith Lake).

The recent collections made within the Kobuk drainage do not appear to be unusual even though they extend the range of this species beyond the limits depicted in Wright and Wright (1949) and Stebbins (1962). Since Hock (1956) knew of the existence of wood frogs at Kiana 20 years ago, Stebbins (1962) must have been either unaware of Hock's report or doubted its accurracy.

It is not really too surprising that the northern limit of the range of the wood frog was not better known until recently. These frogs are not very conspicuous throughout most of the year, the exception being during the spring breeding period. In Interior Alaska, near College, breeding dates have ranged from 24 April to 18 May over a ten year period of observation and these dates seemed to be correlated with variations in spring thaw conditions (Kessel, 1965). Based upon breakup of the Kobuk River, spring thaw occurs between the middle and end of May in the Kobuk Valley (Melchior, PART I, this report), therefore, the breeding period for wood frogs in the Kobuk Valley probably occurs during a time of year similar to that of the Interior Alaska populations. Shortly after the breeding season, the frogs become quite inconspicuous by being sedentary and hiding beneath litter (Kirton, 1974) thereby reducing the probability that biologists who are engaged in summer field work will encounter them.

In the interior, wood frogs enter hibernation in late August and early September and emerge from hibernation just before the breeding period (Kirton, 1974). The hibernacula are shallow (about 4 cm beneath the soil surface) and are located in the vicinity of water (ibid). The hibernation behavior of wood frogs along the northern limit of their range, including the Kobuk Valley, is not known.

Although wood frogs in Interior Alaska produce an average of 778 eggs per egg mass, of which 78 percent are fertile (Kinney, 1966) mortality during development is high. In studies conducted in College, Alaska mortality during the egg to tadpole period averaged 2.5% per day and during the tadpole to juvenile period the loss was 1.2% per day (Herreid and Kinney, 1967). The overwinter survival rate for adult hibernators was not determined but the rate for juvenile frogs was 17% (Kirton, 1974). Since the Kobuk Valley, like Interior Alaska, has a cold, continental climate (Melchior, PART I, this report) Kobuk Valley populations of wood frogs can be expected to suffer comparable losses during the development and hibernation periods.

FISH

Townsend (1887), an early naturalist, reported on 12 species of fish inhabiting the Kobuk River drainage based upon his trip up the river during the summer of 1885. Although several geological survey parties worked within the Kobuk River drainage during the first three decades of the 20th century (Mendenhall, 1902; Smith, 1913; Smith and Mertie, 1930) their reports added nothing new to the knowledge of the ichthyfauna of the Kobuk River. By mid-1950's some additional collections had been made in the region of western Alaska and the Bering Strait and these, together with earlier collections, were analysed by Walters (1955) who prepared an annotated list for western Arctic America and eastern Arctic Siberia and discussed the probable zoogeographic affinities of the fauna. In 1965, Alt (1969), while conducting an ecological study of the inconnu (sheefish), collected 18 species of fish from the Kobuk River. McPhail and Lindsey (1970), in their work on the freshwater fishes of northwestern Canada and Alaska, provide an excellent history of publications pertaining to fish of northwestern Alaska and include distribution maps that identify the general location of collections from freshwater systems of the region, including the Kobuk. The collections enumerated in these reports provide evidence for a fish fauna of 25 species in the Kobuk River drainage. Most of these species probably exist within the boundaries of the proposed Kobuk Valley National Monument, but the deep water habitat required for lake trout, which are found in Walker Lake, may be missing from the proposed KVNM.

1974 Field Data

Most of our field data on fish were obtained from the tributary waters of the Kobuk River although a few specimens were taken from the main river.

Sixty-four fish representing five species were taken by lure and line. Of these, 52 were grayling, 5 were northern pike, 3 were dolly varden/ Arctic char, 3 were chum salmon, and 1 was a broad whitefish.

Grayling

Thirty-nine, or 75% of the grayling were taken from the Salmon River, 11 came from the Kallarichuk River, 1 came from the Akillik River, and 1 was taken from the Kobuk near the mouth of the Salmon River. All of these are clear water streams and represent typical habitat for this species. The 28 males taken had an average fork length of 35.4 cm; the range was from 24 to 42 cm. The 20 females taken had an average fork length of 32.7 cm; the range was from 26 to 37 cm.

Although grayling are noted for their susceptibility to artificial flies (Andrews, 1970), all of ours were taken easily on small Mepps lures, mostly on No. 1 red and white colored spinners.

A crude analysis of the stomach contents of 33 grayling revealed that a high percentage of the fish had eaten worms, adult and larval forms of insects and plant material (Table 1), however, a few had also ingested other fish (sculpin), salmon eggs, and inorganic material such as soil particles and pebbles. Our list of items found in stomachs could be biased in favor of non-aquatic organisms since our trip down the river immediately followed several days of rain (see Melchior, PART I, this report) that probably washed many aerial and terrestrial invertebrate forms into the river. Wojcik (1955) and Schallock (1966) found that the stomachs of grayling inhabiting streams and rivers in interior Alaska showed a preference for aquatic insects throughout the summer except during periods of high water when there was a shift toward terrestrial insects. Vascotto (1970), reported that during rainy days the feeding activities appeared to be nil. He attributed this to the inability of the fish to see drifting food items due to the roiled condition of the water.

Surprisingly, 58% of the stomachs analyzed contained either inorganic material or plant material, which indicates that grayling may not be very discriminating in their feeding, at least during periods of high water. The plant material included grass, pieces of leaves, seeds, sticks up to 2 cm long and spruce needles. Vascotto (1970), who employed spruce needles as a test food item during feeding behavior trials, reported that grayling over 23 cm long "refused to rise or make investigational movements when spruce needles were dropped" into the pool and that fish 15 to 23 cm long would mouth the needles but always rejected them. However, we found spruce needles in the stomachs of five fish ranging in length from 27.2 cm to 42 cm, thus, Vascotto's results may not be representative of grayling feeding behavior with respect to the ingestion of spruce needles.

Six females taken on July 30, or 30% of all the females captured, were carrying eggs. Grayling spawn in streams from late April to mid-June in Alaska and Canada (Andrews, 1970; McPhail and Lindsay, 1970; Schallock, 1966; Wojcik, 1955) so we did not expect to find fish carrying

Table 1. Stomach contents of grayling captured by line and lure from the Salmon River, summer 1974.

Item	Number of fish with item	% fish with item
Inorganic material (soil, pebbles, grit)	5	15
Plant material (organic debris, grass, leaves, spruce needles, seeds, sticks)	15	45
Insect subadult form	14	42
Insect adult forms	12	36
Worms (segmented and nonsegmented)	18	55
Fish (sculpins, other)	3	9
Salmon eggs	2	6
Unidentified material	3	9

well developed eggs at the end of July. Recent studies by Alaska Department of Fish and Game biologists indicate that grayling carry two groups of eggs just before spawning, one sack containing ripe eggs that will be released in May or June and another sack that reach nearly full development and are held through the winter in readiness for spawning the following year (Kim Francisco, Alaska Department of Fish and Game, Fairbanks, personal communication). The fork lengths of females with and without conspicuous sacks of eggs are given in Table 2. Ten females, or 50% of the females sampled, were longer (and presumably older) than the fish with eggs. The absence of conspicuous sacks of eggs in these larger females is puzzling and we have no explanation for this finding.

Salmon

We caught three chum salmon (*Oncorhynchus keta*), all three on a number 3 red and white Mepps lure. Two, a female of 67.5 cm fork length and a male of 70.5 cm fork length taken on July 22nd, were captured from the main Kobuk River in a stretch located about half way between the mouths of the Kallarichuk and the Salmon Rivers. The third one, a male of 68.4 cm fork length taken on August 1st, was caught in the Salmon River.

On August 1, chums were observed in a clear and quiet water side branch of the Salmon River located a few kilometers downstream from the confluence of the Kitlik and Salmon Rivers. They were not yet spawning but the site appeared to be a potential spawning area. Later that day and further downstream, we caught a male chum in fast muddy water of the main channel of the Salmon indicating that some fish were probably still moving upstream toward spawning areas on this date.

As expected of salmon migrating to spawning areas, the stomachs of all three were shrunken and empty.

Arctic Char-Dolly Varden Complex

As has been pointed out by McPhail and Lindsey (1970), there has been a debate among icthyologists as to whether the Dolly Varden represents a species distinct from the Arctic char (*Salvelinus alpinus*). In this report we follow Alt (1969) who refers to the populations in the Kobuk River as the Arctic char-Dolly Varden complex.

We captured a single specimen, a male of 73.8 cm fork length from the Salmon River on July 31 with a number 1 red and white Mepps lure. The stomach was small and empty indicating that this individual was probably from an anadromous population on its way upstream to a spawning area.

Northern Pike

Five pike (*Esox lucius*) were taken, two from Elaroniluk Creek and three from a small pond with a short connection to the northern channel of the Kobuk that lies just east of Kiana. The two from Elaroniluk Creek

Table 2. Fork lengths of female grayling with and without eggs captured between July 27 and August 3, 1974.

Fork length class (cm)	Number of females with eggs	Number of females without eggs
26-27	0	1
27-28	1	1
28-29	1	0
29-30	0	0
30-31	2	0
31-32	0	1
32-33	2	1
33-34	0	2
34-35	0	2
35-36	0	3
36-37	0	2
37-38	0	1
TOTALS	6	14

were 59.5 and 33.7 cm in fork length. This creek is a slow moving stream with dark brown appearing water that enters the Kobuk from the south at a point near the western boundary of the proposed KVNM. The small pond is outside the boundary but it too contained dark appearing water that probably undergoes some exchange with the water of the Kobuk as the latter fluctuates in level. Both of these sites are typical habitat for the species in the north (McPhail and Lindsey, 1970).

Lotic Habitats

No systematic study has been made of the lotic or running water habitats of the proposed KVNM. Our observations revealed striking differences between the tributaries entering the Kobuk River from the north compared to those entering from the south. South-flowing streams and rivers have their headwaters in the high, rugged Baird Mountains whereas the north-flowing streams have their headwaters in the lower, less rugged Waring Mountains. The approximate maximum elevations of the headwaters of north-flowing and south-flowing streams are given in Table 3. In addition to the difference in the height of the vertical fall of water, there are obvious differences in the sizes of the drainages, north-flowing streams generally having much smaller drainages than south-flowing streams. Although no measurements were taken, south-flowing streams are faster running and, except after rainstorms, have clearer-appearing water than north-flowing streams. A third important difference is that runoff water entering the south-flowing streams passes through a different array of substrate and vegetation types than water entering north-flowing streams (see Racine's vegetation map, Fig. 7, this report). Taken together, these differences in topography, substrate and vegetation have created north-flowing and south-flowing lotic systems that appear to have very different physical and biological characteristics. It is probable that further study of the flora and fauna would reflect these differences.

Commercial and Subsistence Fisheries

Since 1962 the Division of Commercial Fisheries, Alaska Department of Fish and Game has gathered data on the commercial and subsistence utilization of salmon and sheefish within the Kotzebue District which includes the Kobuk River drainage. These are the only numerical data on the fish inhabiting the Kobuk River and the Kotzebue region as a whole, consequently, they represent the only measure we have of the relative abundance of certain species. These data have been analyzed and aspects relevant to the Kobuk River drainage are presented here.

The salmon run up the Kobuk consists almost entirely of chum salmon although a few individuals of other salmon species also ascend the river including pink (*Oncorhyncus gorbuscha*), chinook (*O. tshawytscha*), sockeye (*O. nerka*), and coho (*O. kitsutch*). The annual commercial and subsistence harvest of chum salmon and estimates of spawning adults that

Table 3. Approximate maximum elevation at headwaters of north-flowing and south-flowing tributary streams of the Kobuk River.

North-flowing		South-flowing	
Elaroniluk Creek	229 m	Kallarichuk River	457 m
Tetilesook Creek	274 m	Salmon River (including Kitlik and Nikok)	853 m
Unnamed Creek	229 m	Tutuksuk River	914 m
Nigeruk Creek	107 m	Hunt/Akillik Rivers	549 m
Kavet Creek	183 m	Mean Elevation =	648
Ahnewetut Creek	152 m		
Niaktuvik Creek	260 m		
Tunutuk Creek	335 m		
Nakochelik Creek	91 m		
Mean Elevation =	207		

escaped the harvest provide a crude index of year to year fluctuations in relative abundance of salmon in the Kobuk region. The young age classes (one to five years) are at sea where their numbers are nearly impossible to ascertain. The numbers of young salmon migrating down the Kobuk and out to sea have, apparently, not been sampled so there are no data relating to early survival.

The data on sheefish utilization are limited to subsistence and commercial catch statistics; no estimates have been made of the size of the spawning population or of total population size.

Residents of the villages on the Kobuk River participate in both the commercial and subsistence fishing of chum salmon that spawn in the tributaries of the Kobuk. Commercial fishing is carried out primarily in Hotham Inlet and in the waters around the northern tip of the Baldwin Peninsula, in the vicinity of Kotzebue. Subsistence fishing is conducted primarily in the vicinity of the villages in the waters of the main river. Table 4 presents the harvest data for 1962-1975 from both commercial and subsistence fishing within the entire Kotzebue district which includes catches from villages on the Kobuk and Noatak Rivers and the coastal villages of Buckland, Candle, Deering, Kotzebue, and Shishmaref on Kotzebue Sound. Figure 1 graphically compares the commercial and subsistence catches from 1962 through 1975. It is evident that while the subsistence catch has remained approximately the same or perhaps declined slightly during this period, the commercial catch has undergone a dramatic increase since 1970. The impact, if any, of this rise in the commercial chum salmon catch on the fisheries is not known and probably won't be known for three to five years, the period that the young spend at sea. Thus, if the high harvest has reduced the number of spawning fish, which could reduce salmon production, the effect would not be visible before 1976 and beyond.

While the subsistence catch as a percent of the total catch in the Kotzebue District has declined, especially since 1970, the Kobuk River portion of the subsistence catch has increased to more than 50% of the total subsistence catch since 1970 (Table 4). The latter appears to be the result of an increase in the Kobuk River catch and declines in the subsistence catch at Noatak, on the Noatak River, and at Kotzebue (plus the lack of survey data on subsistence catches there for 1974 and 1975).

The Division of Commercial Fisheries makes aerial survey counts of spawning chum salmon each year. Two of the Kobuk tributaries surveyed, the Salmon and Tutuksuk Rivers, lie within the boundaries of the proposed KVNM. A number of factors such as stream condition and weather affect the quality of the surveys, but during the period 1962 through 1975 the counts from these two rivers have, on the average, represented approximately one third of the total count for the entire Kobuk river system. It is possible that this proportion is just an artifact of the survey methods and conditions but if not, then these two rivers may represent very significant spawning habitat for chum salmon. The Kaliguricheark, Hunt and Akillik River systems, which like the Salmon and Tutuksuk flow

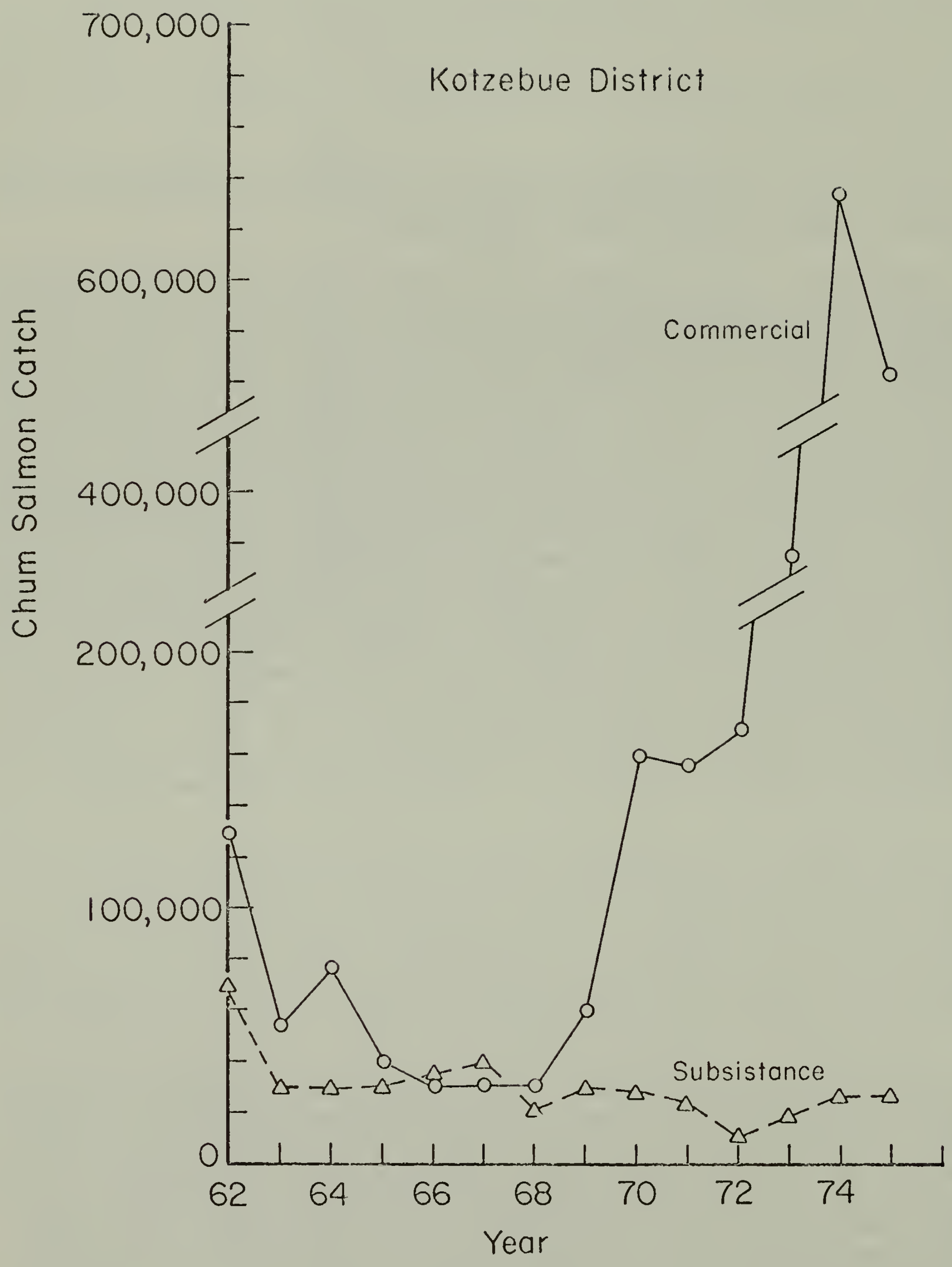

Figure 1. Chum salmon commercial and subsistence catch, Kotzebue District, Alaska, 1962-1975. Data from ADF&G (1975).

Table 4. Commercial and subsistence chum salmon catches, Kotzebue district, 1962-1975. (Excluding catches for 1974 and 1975 from the Deering experimental commercial harvest.) Data from ADF&G (1975).

Year	Commercial catch	Subsistence catch	Combined catches	Subsistence catch as % of combined	Kobuk River subsistence catch as % of total district subsistence catch
1962	129,948	70,283	200,231	35	-
1963	54,445	31,069	85,514	36	27
1964	76,499	29,762	106,261	28	31
1965	40,034	30,500	70,534	43	38
1966	30,764	35,588	66,352	54	17
1967	29,400	40,108	69,508	58	15
1968	30,384	20,814	51,198	41	38
1969	59,335	29,812	89,147	33	39
1970	159,664	28,486	188,150	15	58
1971	154,956	23,959	178,915	13	60
1972	169,664	11,085	180,749	6	85
1973	375,432	18,942	394,374	5	77
1974	627,912	26,729	654,641	4	74
1975	552,641	27,605	580,246	5	84

out of the Baird mountains, represent additional but unsurveyed salmon spawning habitat that lies within the boundaries of the KVNM. The total salmon spawning habitat potential of the lotic systems within the KVNM is unknown.

The sheefish, or inconnu (Stenodus leucichthys) that spawn in the Kobuk River in summer, winter in Selawik Lake and Hotham Inlet (Alt, 1969). The main spawning area is above the village of Kobuk and in the main channel of the Kobuk River, thus sheefish pass through the KVNM on their way to and from the spawning grounds.

After chum salmon, sheefish are probably the next most important fish to subsistence fisherman living along the Kobuk River. Table 5 presents data on the subsistence catch of sheefish by fisherman from the Kobuk River villages, the total subsistence catch for the Kotzebue District, the Kobuk catch as a percent of the total subsistence catch, the commercial catch (primarily Kotzebue) and the commercial catch as a percent of the combined commercial and subsistence catch. The most obvious and impressive feature of these data is the year to year variation in the size of the catches.

Furthermore, the Kobuk catch as a percent of the total subsistence catch increased steadily between 1968 and 1972 but since 1971, the number of fish taken by Kobuk fisherman has declined. It is unclear from these data whether or not they signal a decline in the fishery or simply a reduction in fishing effort.

Figure 2, which is a plot of the mean catch per fisherman for both chum salmon and sheefish from 1962 through 1975, shows that as the mean catch per fisherman of chum salmon has risen, the mean catch per fisherman of sheefish has tended to decline. There are several possible explanations of these trends, that is the declining catch and the declining catch per fisherman, but the two most probable explanations are: (1) that less fishing effort has gone into catching sheefish because the chum salmon have been so abundant in recent years, and (2) that the sheefish population is declining. The existing data are not sufficient to determine which one of these is most likely. Both explanations might represent the best interpretation of the data.

There are no data on the productivity of fish species inhabiting the Kobuk River drainage or any drainage within the northwestern region of Alaska. Indeed, the only quantitative data available are the subsistence and commercial harvest data and the rough estimates of the number of spawning chum salmon in some tributaries of the Kobuk reported above. Although a large female chum may contain as many as 4000 eggs, (McPhail and Lindsey, 1970), estimates of the total number of eggs laid or the number of fry surviving the downstream migration to estuarine waters are not available.

BIRDS

The first serious enumeration of the birds of the Kobuk River area seems to have been McLenegan's (1889b) list with notes of 83 species that

Table 5. Subsistence and commercial sheefish catches, Kobuk River and Kotzebue District, 1967-1975. Data from ADF&G (1975).

Year	Kobuk Catch	Total District Subsistence Catch	Kobuk Catch as % of District Catch	Comm. Catch	Comm. Catch as % of Total Catch
1967	5,176	22,400	23	992	4
1968	4,342	31,293	14	2,375	7
1969	3,370	11,872	28	2,206	16
1970	8,807	13,928	63	350	2
1971	9,485	13,583	70	456	3
1972	3,521	3,832	92	2,325	38
1973	4,888	-	-	-	-
1974	1,062	-	-	-	-
1975	1,637	4,270	38	-	-

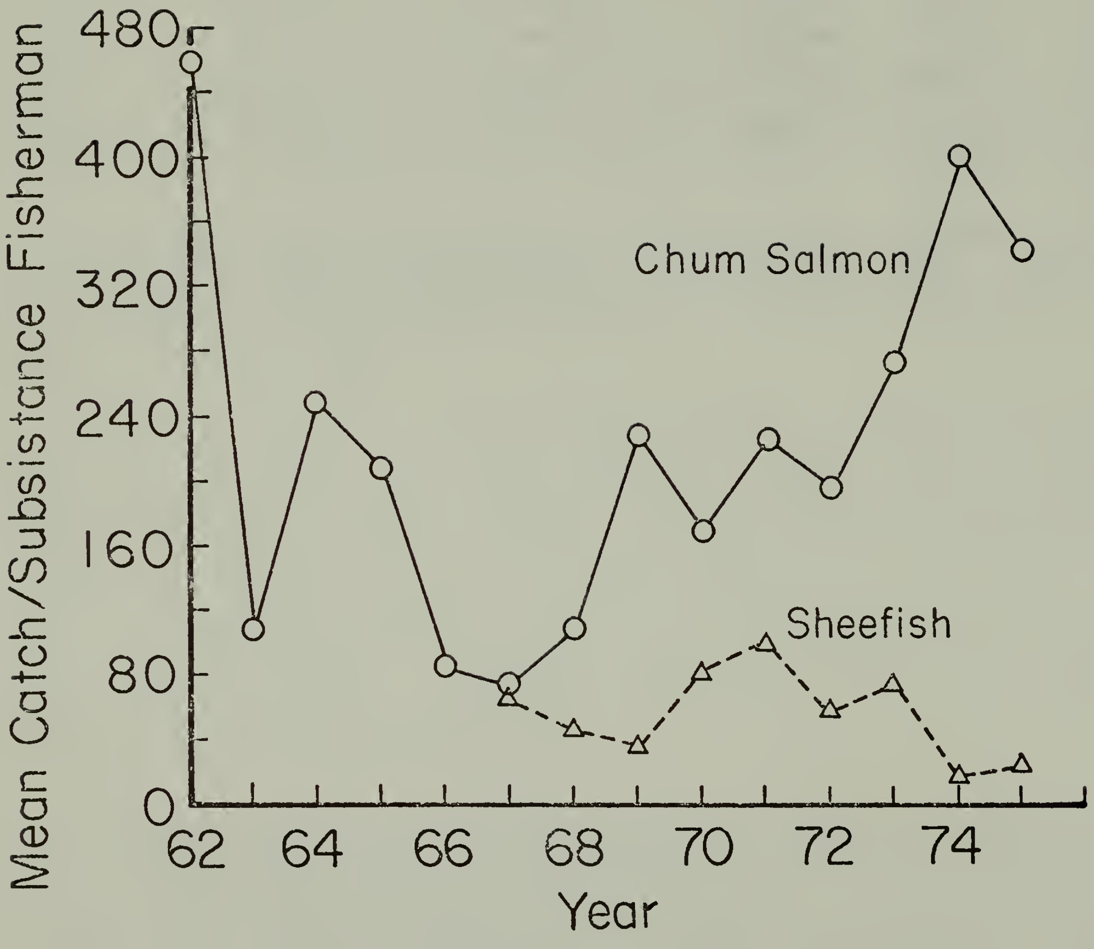

Figure 2. Mean catch per Kobuk River subsistence fisherman for chum salmon and sheefish, 1962-1975.

resulted from his explorations of the river in the summer of 1884. This was followed by Grinnell's (1900) major work on the birds of the Kotzebue region and a few studies of a localized nature. Dean and Chesemore (1974) reviewed all of the earlier works, and added their own observations of birds made in the upper Kobuk River drainage to those found elsewhere in the drainage. They published a table (Table 2) listing all the species that had been reported along with information of the relative abundance and nesting status for each species as it had been reported.

Our observations of birds seen within the boundaries of the proposed KVNM were recorded as time and travel permitted. We made no attempt to record birds each time we saw them, unless they represented a species not previously seen by us, the objective being to record every species we saw even though we had entered the field too late to attempt a complete census of the species present. We did see 63 species, however, and have listed them along with the dates and location seen in Table 6. The number of entry's for a species is not a reliable indication of the relative abundance of the species. Since our observations were made during July and August, it is likely that the species we saw were all summer residents of the area rather than migrants.

We added only one new bird to the list compiled by Dean and Chesemore (1974), the Black-legged Kittiwake, which we found to be common in the vicinity of Kiana and that portion of the Kobuk River that lies between Kiana and the western edge of the proposed KVNM.

No estimates of population size or the density of breeding birds exist for the habitats within the proposed KVNM. The review of previous studies by Dean and Chesemore (1974) includes estimates of relative abundance of both breeding and non-breeding birds using an ordinal scale consisting of four categories: rare, uncommon, common, and abundant. Unfortunately, most of the observers whose reports they reviewed spent little time during the breeding season within that portion of the Kobuk drainage in which the proposed KVNM lies.

In 1973, Manuwal (1974) made estimates of breeding bird populations at the western edge of the Noatak River delta, approximately 130 km west of the proposed KVNM, in three habitat types: lacustrine waters and marsh; willow-spruce thicket; and open spruce forest. He reported densities of 247 pairs per square km, 1062 pairs per square km, and 1062 pairs per square km in the three types respectively, and acknowledges that the densities of the two habitats containing spruce, which yield higher estimates than those reported for most other coniferous forests, may be excessively high due to the small size (2 ha) of his sample plots and the movement of non-breeding birds through them. In an interior mixed deciduous-coniferous forest, West and DeWolf (1974) reported 53 pairs per square km and 149 pairs per square km in two sample areas, values that are much lower than those reported by Manuwal. However, his data represent the only available estimates of breeding bird densities within northwestern Alaskan woodland habitats.

Table 6. Birds observed in fall 1973 and summer 1974 and dates and locations seen, in the area of the proposed Kobuk Valley National Monument.

Species	Date	Location	Comments
Common Loon	7/22	Elaroniluk C.	-
Arctic Loon	7/22	Kobuk R. at VABM Goldie	-
	8/1	Lower Salmon R.	-
	8/3	Kobuk R. at "Kittiways"	-
	8/5	Mouth of Kallarichuk R.	-
	8/6	Kallarichuk R.	-
	8/8	Middle Kobuk R.	-
	8/10	Confluence of Akillik R. and Nekakte C.	-
	8/16	Kobuk R. near Ambler	2 birds
Red-throated Loon	7/31	Middle Salmon R.	-
	8/7	Middle Kobuk R.	-
	8/8	Middle Kobuk R.	-
Canada Goose	7/31	Middle Salmon R.	Pair + 5 young
	8/1	Lower Salmon R.	2 broods
	8/5	Kobuk R. slough by VABM "Goldie"	Many birds, with white fronted geese
	8/10	Hunt R.	-
	8/12	Upper Kobuk R.	-
White-fronted Goose	8/5	Kobuk R. slough by VABM "Goldie"	Many birds, with Canada Geese
	8/5	Lake off slough	3 adults + 10 young - 2 adults + 7 young
	8/5	Blind slough near "Goldie"	-
	8/8	Middle Kobuk R.	20 birds
	8/8	Ahnewetut C.	7 birds
	8/10	Confluence of Akillik R. and Nekate C.	-
Green-winged Teal	8/3	Kallarichuk R.	Female + 3 chicks
	8/5	Kobuk R. slough near VABM "Goldie"	Pair
American Wigeon	7/23	Elaroniluk C.	Female + 4 young
	7/23	Lake by Lower Kobuk R.	Female + 10 young
	8/3	Lower Kobuk R.	Female + 3 young
	8/5	Kobuk R. slough near VABM "Goldie"	-
	8/5	Lake off Kobuk R. slough	Female
	8/16	Kobuk R. near Ambler	-

Table 6. Continued

Species	Date	Location	Comments
Red-breasted Merganser	7/29	Tributary C. of upper Salmon R.	Female + 10 young
	7/30	Middle Salmon R.	Female + 11 young
	7/30	Middle Salmon R.	Female + 10 young
	7/31	Lower middle Salmon R.	Female + 11 young
	8/5	Mouth of Kallarichuk R.	Female + 5 young
Rough-legged Hawk	7/27	Salmon R. at Sheep C.	Pair + at least 1 young
Golden Eagle	8/20	Tutuksuk R.	-
Marsh Hawk	7/19	Upper Salmon R.	Male
	7/19	Middle Salmon R.	Female
	7/20	Kennicott cabin on Kobuk R.	-
	7/22	Kobuk R. below Salmon	-
	7/23	Elaroniruk C.	-
Osprey	7/22	Kobuk R. at VABM "Goldie"	-
Merlin	8/21	Kobuk Dunes	-
	8/24	Baird Mts. near "OCA" Lake	-
American Kestrel	7/27	Lower Sheep C.	Pair
Spruce Grouse	8/9	Hunt R. Dunes	-
	8/11	Hunt R. Dunes	-
	8/21	Old burn SW of Kobuk Dunes	-
Sandhill Crane	7/21	Kobuk R. near Hunt R.	2
	8/8	Middle Kobuk R.	-
	8/9	Hunt R.	2
	8/10	Hunt R.	-
	8/11	Kobuk R. above Hunt R.	-
	8/12	Upper Kobuk R.	-
	8/17	Kobuk Dunes	-
Semipalmated Plover	7/22	Lower Kobuk R.	Pair
Common Snipe	7/26	Anaktok C.	-
	7/31	Salmon R. below Kitlik R.	-
	8/5	Kobuk R. slough by VABM "Goldie"	-

Table 6. Continued

Species	Date	Location	Comments
Common Snipe (Cont.)	8/9	Kobuk R. at Ahnewetut C.	4 birds
Wimbrel	8/8	Middle Kobuk R.	-
Wandering Tattler	7/26	Sheep C.	Pair
Lesser Yellowlegs	7/22	Kobuk R. slough 5 km below Salmon R.	-
	7/22	Mouth of Kallarichuk R.	Pair
	8/5	Kobuk R. by "Goldie"	2 birds
	8/9	Kobuk R. at Ahnewetut C.	-
Pectoral Sandpiper	8/19	Waring Mountains	-
Semipalmated Sandpiper	8/2	Kiana	-
	8/19	Waring Mountains	-
Glaucous-winged Gull	7/23	Kiana	-
	7/31	Salmon R. below Kitlik R.	10 birds
Mew Gull	7/21	Kobuk R. at Salmon R.	-
	7/23	Kiana	-
	7/27	Upper Salmon R.	-
Bonaparte's Gull	7/23	Kiana	-
	7/24	Kiana	-
	7/25	Kiana	-
Black-legged Kittiwake	7/22	Kobuk R. at VABM "Goldie"	-
	7/23	Kiana	-
Arctic Tern	7/21	Kobuk R. near Hunt R.	-
	7/23	Kiana	-
Great Horned Owl	7/23	Elaroniruk C.	-
	8/5	Kobuk R. at VABM "Goldie"	-
	8/7	Kaliguricheark R.	-
	8/9	Ahnewetut C.	3 birds
Short-eared Owl	7/20	Kennicott Cabin on Kobuk R.	-
Belted Kingfisher	7/20	24 km below Ambler on Kobuk R.	-

Table 6. Continued

Species	Date	Location	Comments
Belted Kingfisher (Cont.)	8/4	Kallarichuk R.	4 birds
Common Flicker	8/21	Kobuk Dunes	-
Northern Three-toed Woodpecker	7/31	Lower Salmon R.	-
	8/16	Kobuk slough near Ambler	-
	8/19	Kobuk Dunes	-
Olive-sided Flycatcher	8/4	Kallarichuk R.	-
Tree Swallow	7/23	Kiana	-
Bank Swallow	7/20	Kobuk R. Bluffs 24 km below Ambler	-
Cliff Swallow	8/4	Kallarichuk R.	-
Gray Jay	7/26	Sheep C.	-
	7/29	Salmon R. ca. 5 km below Sheep C.	-
	9/18/73	Ahnewetut C. at Kobuk Dunes	-
Common Raven	7/26	Sheep C.	4 birds
	7/29	Upper Salmon R.	2 birds
	7/31	Middle Salmon R.	-
	8/1	Lower Salmon R.	-
	8/10	Akillik R.	-
	8/24	Baird Mts. near "OCA" Lake	-
	9/16/73	Ahnewetut C. at Kobuk Dunes	-
Boreal Chickadee	7/31	Middle Salmon R.	-
	8/8	Middle Kobuk R.	-
	8/9	Hunt R. Dunes	-
Dipper	? 7/30	Middle Salmon R.	Poor light con.
American Robin	7/26	Sheep C.	-
	8/19	Kobuk Dunes/Waring Mts. base	-

Table 6. Continued

Species	Date	Location	Comments
Varied Thrush	7/26	Sheep C.	-
	7/30	Salmon R. below Nikok R. mouth	-
Swainson's Thrush	8/18	Kobuk Dunes	-
Wheatear	? 7/26	Sheep C.	Poor light con.
	8/19	Waring Mts.	-
	8/21	Kobuk Dunes	-
Yellow Wagtail	8/18	Kobuk Dunes	-
Water Pipit	8/19	Kobuk Dunes	-
Bohemiam Waxwing	8/4	Kallarichuk R.	-
	8/10	Junct. of Akillik R. and Nekakte C.	-
	8/18	Kobuk Dunes	-
Northern Shrike	8/15	Near Ambler	-
	9/16/73	Kobuk Dunes	2 immatures
Yellow Warbler	8/5	Kobuk R. at VABM "Goldie"	-
	8/7	Kaliguricheark R.	-
	8/9	Hunt R. Dunes	-
Myrtle Warbler	8/7	Kaliguricheark R.	-
	8/8	Upper middle Kobuk R.	-
	8/10	Akillik R. and Nekakte C.	-
Blackpoll Warbler	8/4	Kallarichuk R.	-
Northern Waterthrush	8/9	Ahnewetut C.	-
Wilson's Warbler	7/26	Sheep C.	-
	8/18	Kobuk Dunes	-
Rusty Blackbird	7/23	Kiana	-
	8/9	Ahnewetut C.	-
Pine Grosbeak	7/22	Salmon R. mouth	-
	7/31	Middle Salmon R.	-

Table 6. Continued

Species	Date	Location	Comments
Pine Grosbeak (Cont.)	8/1	Salmon R. 6 km below Kitlik R.	-
	9/18/73	Upper Ahnewetut C.	-
Redpoll cmpx	7/26	Sheep C.	-
	7/27	Salmon R. mouth of Sheep C.	-
	8/9	Ahnewetut C.	-
	8/9	Hunt R. Dunes	-
	8/21	Kobuk Dunes	-
Savannah Sparrow	8/18	Kobuk Dunes	-
Dark-eyed Junco	8/18	Kobuk Dunes	-
Tree Sparrow	8/5	Kobuk R. at VABM "Goldie"	-
	8/7	Kaliguricheark R.	-
	8/9	Hunt R. Dunes	-
	8/10	Akillik R. and Nekakte C.	-
	8/18	Kobuk Dunes	-
White-crowned Sparrow	7/27	Upper Salmon R.	-
	8/18	Kobuk Dunes	-
Fox Sparrow	8/7	Kaliguricheark R.	-
	8/11	Akillik R.	-
	8/11	Hunt R. Dunes	-
Lapland Longspur	8/19	Waring Mountains	-

Breeding bird densities of tundra habitats within the Ogotoruk Creek drainage, which lies approximately 190 km northwest of the proposed KVNM, were estimated by Williamson, Thompson and Hines (1966). Densities ranged from a low of 59 pairs per square kilometer in a *Carex* meadow tundra to a high of 479 pairs per square kilometer in riparian willow.

Measurements of productivity of the avifuana within the proposed KVNM have not been made but Williamson, Thompson and Hines (1966) were able to gather data on nesting and fledging success for 13 tundra species (see their Tables 13, 14 and 15). Success ranged from a low of 14% eggs fledged for redpolls to nearly 100% for some shorebird species. However, avifaunal productivity at northern latitudes is often affected by climatic events and their sometimes catastrophic influence on nesting success (Williamson, Thompson and Hines, 1966). Since the Kobuk Valley exhibits pronounced variation in climate seasonally and annually (Melchior, PART I, this report), it is likely that avifaunal productivity within the valley experiences marked variation as well.

MAMMALS

Past and Present Status

Small Mammals

The presence of some small mammals within the Kobuk Valley was noted by early nonnative explorers (e.g., Townsend, 1887; Grinnell, 1901) and were known to the native residents. In the summer of 1963, Dean and Chesemore (1974) made surveys of small mammals by trapping in the vicinity of their camps at "Redstone" Lake and Walker Lake both of which are east of the proposed KVNM. But, as they point out, their data are necessarily limited to qualitatively assessing geographical and ecological aspects of the small mammal distributional records obtained during the summer of 1963 at the two locations they visited. The data are not sufficient for evaluating population levels. Aside from the very limited trapping and observational records we obtained during our visit to the Great Kobuk Sand Dunes, September 16 through 19, 1973, together with our 1974 summer observations we are unaware of any other small mammal surveys of the proposed KVNM or, more broadly, the Kobuk River drainage.

The limited records of small mammals within the proposed KVNM that we obtained, are discussed briefly here.

Shrews

Two specimens of the dusky shrew, *Sorex obscurus*, were captured in the vicinity of Ahnewetut Creek, one from a sandy beach covered by monocots (primarily *Carex aquatilis*) and small shrubs (*Andromeda polifolia*, *Potentilla fruticosa*, *Saxifraga oppositifolia*, *Salix* spp.); and one from a dense spruce stand with a moss-covered forest floor. On the beach, the

shrew was associated with the tundra vole (Microtus oeconomous) and in the spruce forest, it was associated with the red-backed vole (Clethrionomys rutilus).

Rodents

Only three species of rodents, the tundra vole, the red-backed vole, and the porcupine are dealt with under this heading; other rodents are considered under the section on furbearers.

We captured five individuals of Microtus oeconomus, the tundra vole, on a meadow-like sandy bench next to Ahnewetut Creek. Carex aquatilis and C. membranacea dominated the vegetation but several low shrub species not normally associated with these carices were also present (see listing given above). A relatively short distance from the bench, a patch of white spruce forest provided habitat for Clethrionomys rutilus, the red-backed vole. We caught five individuals on the trapline in this habitat but we also caught by hand, an individual that was running across the sand out from the forest into an area where stunted, widely spaced Populus balsamifera was growing. An immature Northern Shrike flew toward the animal but our presence apparently caused it to veer off.

On the morning of July 29, a red-backed vole visited our camp on the upper Salmon River making three trips into the camp site to collect bits of bread that had fallen onto the ground. The site was a gravel terrace supporting a mixture of white spruce, cottonwood, and several species of tall willows.

Although these represent very limited observations, the habitat types in which the two species were found are similar to those from which these species were collected by other investigators (e.g., Bee and Hall, 1956; Dean and Chesemore, 1974; Gardner, 1974; Mayo, 1963; Melchior, 1974b; Pruitt, 1966).

On September 17, 1973 a porcupine was observed, and later collected, crossing the Great Kobuk Sand Dunes west of Ahnewetut Creek. The course it was taking was roughly parallel to the edge of the forest that lies next to the creek, but within the zone of occasional spruce. When approached, it headed for and proceeded to climb a spruce tree isolated from the nearby forest. This was the only direct observation of the porcupine we made but the distinctive tracks of this species were seen at several locations along the Kobuk River and some of its tributaries. Evidence of bark feeding by porcupine was found on spruce trees adjacent to Sheep Creek and on the upper portion of Anaktok Creek where Racine (PART II, this report) felt the damage from feeding may have been responsible for the death of many trees. Although evidence of porcupine feeding was seen elsewhere, the extent of damage to trees was relatively minor except at the Anaktok Creek site.

The porcupine has been a member of the Kobuk drainage fauna for at least the past 90 years since Cantwell (1887) "observed many fresh signs of bear, porcupine, and deer along the river banks" during his explorations in 1885.

Hares

The final environmental impact statement of the proposed Kobuk Valley National Monument states: "the monument supports mammals of the tundra, e.g., arctic hare ...; and mammals of the forest, e.g., snowshoe hare ..." (Ak Planning Group, n.d., p. 67). In our review of the literature, we came across only two early references to the tundra (= Arctic) hare, *Lepus othus*, and neither of these placed the hare within the proposed Kobuk Valley National Monument. During his exploration of the Kobuk River region in the summer of 1884, Cantwell (1889, p. 69) mentions that their party shot an Arctic hare in an area about halfway between the mouths of the Kobuk and Selawik Rivers and Townsend, who accompanied Cantwell on his trip up the river in the summer of 1885, mentions "polar hares in the delta of the Kobuk" (Townsend, 1887, p. 85). Anderson's (1974) study of the tundra hare in western Alaska did not reveal the existence of any authentic record or collection of this species from the Kobuk drainage above the delta. However, we know from faunal remains found in an archaeological site at Ogotoruk Creek and dated at 1750-1780 (Hadleigh-West, 1966), that the tundra hare must have existed near the coast north of the Kobuk 200 to 250 years ago, but it is not present there now (Pruitt, 1966). We found no evidence of this species during our study. Apparently, the tundra hare, found in the coastal region in precontact and early contact times, has been extirpated from the region.

None of the earliest explorers of the Kobuk River, such as Cantwell (1887, 1889), McLenegan (1889a), or Townsend (1887), mentions the presence of snowshoe hares in the valley although at least one of them (McLenegan) reported that lynx, a primary predator of snowshoe hare, was abundant in the region (McLenegan, 1889a, p. 108). If their travels coincided with a cyclical low in hare populations, the absence of any mention of hares would not be surprising. This species was present in the valley in the 1960's (Dean and Chesemore, 1974) and at times, reach dense populations (Henshaw, 1966). We observed hares or their sign at six locations within the proposed KVNM. Droppings were found along Sheep Creek and young animals were seen on two separate days near our first canoe camp on the upper Salmon River. Fresh tracks were seen at four sites along the Kobuk River: near the mouth of the Kallarichuk River, across from the coal mine, by the Hunt River Dunes and across from Kantner's residence upriver from the mouth of the Hunt River. In view of the scarcity of our sightings, the hare population within the proposed Monument was probably in the low part of its cycle in 1974.

Furbearers

Furbearers, that is mammals utilized primarily for the quality of their fur, are treated under four headings: Mustelids, Canids, Felids, and Rodents. Only fox and coyotes are treated under Canids in this section, wolves are discussed under the heading Big Game. This division is purely arbitrary but reflects the greater interest in and significance of the wolf compared to fox and coyotes. Furthermore, the wolf is classified both as a big game animal and as a furbearer in Alaska.

Mustelids

The Mustelids of the proposed KVNM include weasels, mink, marten, wolverine and river otter. McLenegan (1889a, p. 108) remarked that "Land Otter" were more or less common and that marten were abundant in the mountain districts. Townsend (1887, p. 89) said he saw 2-3 wolverine skins among the natives their party visited but he did not know where the skins originally came from. He reported seeing a mink on the upper river and pelts in all the villages. Ermine skins were common among the natives. Smith (1913), who worked in the valley about 15 years later, commented that marten and mink "used to be fairly common but are yearly becoming scarcer".

Foote (1966) points out that during the early 1900's most of the men living along the river spent the winter trapping, there being a good market for furs during this period, but that during the depression years of the early 1930's, fur prices dropped. They continued to trap, however, as there were few alternative means of acquiring cash and they used fur for their own clothing as well as a source of income.

In 1954, Woolford (n.d.) obtained harvest information from four Kobuk villages; the take of weasels (probably ermine), mink and otter, are shown in Table 7. From these harvest figures, it would appear that there were good populations of weasels and especially mink in the valley but that otter were not very abundant. Dean and Chesemore (1974), who were in the Noatak River and the upper Kobuk River drainages in 1963, captured one least weasel and saw tracks of a single mink during the entire summer and neither of these were found within the Kobuk drainage.

Fur export and estimated harvest from GMU 23 for the mid-1960's are shown in Table 8. The proportion of this harvest attributable to the Kobuk River drainage is not known.

We made no direct observations of any mustelid during our investigations but fresh tracks were found of otter and wolverine. Otter tracks were recorded at six locations: Kobuk River one km below Hunt River, mouth of Salmon River, lower Salmon River, 16 km upriver from Kallarichuk River mouth, lower Kallarichuk River, and Kobuk River across from the coal mine. During the summer, 1974, wolverine tracks were found along

Table 7. Reported furbearer harvest by village, Kobuk River drainage, 1954. (Data from Woolford, n.d.)

Village	Species						
	Weasel	Mink	Otter	Red Fox	Wolves	Beaver	Muskrat
Kobuk	35	98	4	-	-	26	-
Shungnak	13	30	2	7	10	-	-
Kiana	-	50	-	-	13	-	6,000
Noorvik	-	308	-	-	-	-	5,600
TOTALS	48	486	6	7	23	26	11,600

Table 8. Fur exports (1964-1965) and estimated harvest (1965-1966 and 1966-1967) from Game Management Unit 23, Alaska. (Data from Burris, 1966; 1968; 1969.)

Period	Species							
	Weasel	Mink	Marten	Otter	Red Fox	Lynx	Beaver	Muskrat
1964-65	11	387	12	267	8	29	4	10,974
1965-66	10	560	0	10	40	220	0	900
1966-67	20	340	0	10	20	40	0	3,160

the lower Kallarichuk River and at the Great Kobuk Dunes; in March 1975, tracks in the snow were observed along the top of the embankment of the Kobuk River near the Lichen Woodland located about the middle of the course of the Kobuk River as it passes through the proposed KVNM and another set of tracks crossed the Kobuk River near the mouth of the Salmon River.

Current harvest and hunting pressure on weasels and mink are reported as low and data on composition and productivity of the populations are lacking (Pegau, 1974b, 1975). A few land otters are reported taken within Game Management Unit 23 each year and their tracks are commonly seen along the major rivers but no estimates of population size or productivity are currently available (ibid).

The recorded harvest of wolverine within GMU 23 has ranged from one, in 1960-1961, to 55 in 1972-1973, between 1959 and 1973 but many harvested animals are not reported and thus go unrecorded (Pegau, 1974a). Of the record 1972-1973 harvest, "over one-third were taken near Kiana and the rest were equally divided between Noatak, Ambler, Kobuk and Selawik" (ibid).

Canids

McLenegan (1889a) reported that red, white and cross (= color phase or red) fox were abundant in the Kobuk River region in 1884. Townsend (1887) commented that he often saw skins of these foxes during his trip up the river in 1885. Mendenhall (1902) mentioned that red and white foxes "are caught in limited numbers", and Smith (1913) included fox as among those species he felt use to be common but were gradually declining in numbers. Woolford (n.d.) reported a few red fox (*Vulpes vulpes*) being taken by residents of Shungnak in 1954 (Table 7), but at no other village. During the mid-1960's, relatively few red fox were being harvested from the whole of GMU 23 (Table 8); the proportion of the harvest that came from the Kobuk River drainage is unknown. Dean and Chesemore (1974) reported finding an "old fox den" just north of "Redstone Lake", but found no positive evidence of this species at Walker Lake.

We made one direct observation of a red fox at Kiana and recorded tracks at fourteen locations, thirteen within the boundaries of the proposed KVNM and one just upriver of the eastern boundary. Although red fox appeared to occur throughout the area, they were certainly not abundant. We saw no evidence of white fox (*Alopex lagopus*).

Although some authors list the coyote (*Canis latrans*) as present or probably occuring within the Kobuk River drainage (e.g., Ak Planning Group n.d.; Dean and Chesemore, 1974; Foote, 1966), we saw no evidence of the species nor have we found any authentic historical record of its presence based upon our review of published and unpublished accounts.

Felids

McLenegan (1889a) and Smith (1913) both mention that lynx (Lynx canadensis) were present in the region during their travels but neither Townsend (1887) nor Mendenhall (1902) reported the species present.

Lynx exhibit major fluctuations in numbers throughout North America (Keith, 1963). Their numbers usually follow changes in abundance of the snowshoe hare, their major prey species. It is not surprising, then, to have one observer report lynx as common and another to be unaware of their presence if they traveled through a region in different years. The marked change in harvest from 1964-1967 (Table 8) could reflect such a change in abundance. In recent years, the lynx harvest for GMU 23 was reported as remaining below 40 and numbers were judged "moderate" (Pegau, 1974b) for 1972 but increasing on the lower Kobuk in 1973 (Pegau, 1975).

We found no evidence of this species within the proposed KVNM but as mentioned above, since their numbers fluctuate considerably, our inability to detect them during the brief periods we were in the field is not significant evidence of absence or lack of habitat.

Rodents

The major furbearing rodents in the Kobuk region are the Arctic Marmot (Marmota broweri), the Arctic ground squirrel (Citellus parryi), the red squirrel (Tamiasciurus hudsonicus), the beaver (Castor canadensis), and the muskrat (Ondatra zibethicus). Although beaver and muskrat are mentioned as present within the region by all the early travelers of the Kobuk (McLenegen, 1889a; Mendenhall, 1902, Townsend, 1887; Smith, 1913), none mention the marmot, the ground squirrel, or the red squirrel. Like earlier visitors to the valley, Woolford (n.d.) did not include sciurids among the species taken by villagers in 1954 but Heller and Scott (n.d.) and Foote (1966), all of whom spent time in Shungnak during the late 1950's and early to mid-1960's, mention that residents of that village regularly hunt or trap both "Parka" squirrels (= Arctic ground squirrel) and marmots "up in the mountains".

We found no evidence of marmots within the proposed KVNM but then we did not survey from the ground a number of regions within the Baird Mountains where habitat for this species might exist. The general scarcity of alpine meadow habitat adjacent to rock outcrops and talus slopes, however, probably means that one should not expect to find many marmots living in the area, if they occur there at all. Dean and Chesemore (1974) reported finding a marmot den on top of a mountain situated between the Noatak and Squirrel River drainages to the west of the proposed KVNM. Local residents reportedly hunt marmots in the mountains to the east of the proposed KVNM.

Arctic ground squirrels were not abundant nor were signs of their occupancy. We made direct observations of this species along the upper Anaktok Creek, the upper Sheep Creek, the Kaliguricheark River, and the hills around "OCA" Lake. This species is widespread in Alaska occurring in alpine and arctic tundra nearly everywhere it occurs within the state. Having well-drained sites for burrow construction along with a moderate variety of tundra plant species for food seem to be the only major requirements for the species within the general tundra habitat types (Melchior, 1965). It was surprising to us that evidence of this species was not more common but we did not examine very much of the potential habitat of this species during our visits to the proposed KVNM area. Dean and Chesemore (1974) reported that Arctic ground squirrels were less abundant than expected in the Noatak and upper Kobuk River drainages.

During the summer of 1974, we found red squirrels were common wherever there were stands of spruce, especially white spruce. They were present on the upper Salmon River nearly to the limit of spruce distribution and occurred in small, mature stands of spruce adjacent to Ahnewetut Creek where it passes through the Kobuk sand dunes. Deep trails and spruce scale middens suggested long-term occupancy in these patches of spruce.

Mendenhall (1902) commented that muskrat were "very abundant in the Kowak delta" and Smith (1913), who was on the delta in 1910, said they were very numerous. Residents of both Kiana and Noorvik took large numbers of muskrats in 1954 (Table 7), but apparently none were harvested by residents of the upper villages. Data from the mid-1960's (Table 8) show a substantial harvest in the winter of 1964-1965 followed by two winters of much lower harvests. Since muskrats are near the northern limit of their range in the Kobuk region, their abundance may well be a function of the severity of winter conditions as suggested by these comments relating to winter conditions in Alaska in the mid-1930's:

> "Severe cold weather during the past several winters has seriously reduced muskrats by freezing them out of all shallow lakes and swamps. Due to their prolific breeding habits, however, it requires only a few favorable winters to restore them to their former abundance." (Ak. Game Comm., 1936)

During the summer, 1974, we observed a young muskrat swimming across and along the shore of "OCA" Lake, a small lake in a saddle of the Baird Mountains near the eastern edge of the proposed KVNM. There was a beaver dam across the outlet of this lake which probably meant that a fairly high water level was maintained the year around. This could allow muskrats to overwinter if the pond was deep enough but we did not sound the pond. We also found muskrat tracks below Nikok Creek but at no other location.

There are numerous lakes and ponds in the valley of the Kobuk that lie within the proposed KVNM but since we were unable to examine most of them, we have no information regarding their potential to support muskrats.

Both McLenegan (1889a) and Townsend (1887) noted that beaver were "found sparingly" and that the skins were "not plentiful among the natives", remarks that suggest beaver were not easily obtained by residents of the Kobuk River in the late 1800's. Mendenhall (1902) noted that "occasionally ... beaver ... skins are offered for sale." Woolford (n.d.) reported 26 beaver harvested by residents of Kobuk in 1954 but none were taken, apparently, by residents of the other Kobuk River villages. Heller and Scott (n.d.), talking about the residents of Shungnak in the late 1950's stated that "beaver can be trapped in some areas but at a considerable distance from the village." During the summer of 1974, Mark Cleveland of Ambler, and formerly of Shungnak, told us that in the 1920's Kobuk River residents had to go to the Hog River for beaver, then in later years (1930's) the beaver moved into the Pah River flats and finally down along the main Kobuk. Libby (1954) reported that during the early 1950's, trappers from Selawik and Shungnak trapped illegally in the Alatna, Hughes and Huslia region of the Koyukuk River drainage suggesting that beaver were not readily available in the vicinity of their villages.

Statewide, beaver were abundant in the last half of the eighteenth century but then declined and became very scarce by the first decade of the twentieth century (Hakala, 1952). Between 1910 and 1930, the taking of beaver was permitted only in 1921, 1922, 1926, 1927 and 1928, during all other years the season was closed. The results of these regulations apparently helped beaver populations to increase and expand back into areas formerly occupied (ibid). However, records are not available to show whether or not this took place in the Kobuk River area. The expansion of beaver into the middle Kobuk Valley noted above, may have been due to other factors.

During the summer, 1974 we recorded the presence or sign of beaver as we travelled the rivers and on August 26th, we flew many of the drainages looking for dams and lodges. The results are shown in Table 9.

Hakala (1952), Libby (1954), and Boyce (1974) reported the mean number of beaver per colony (or lodge) to be 4.0, 4.0 and 4.32, respectively, in their interior study areas. Murray (1961) and Koontz (1968), following Hakala and Libby, used a mean of 4 beaver per lodge in estimating densities for their study areas but Boyce, arguing that it was unlikely that all the beaver, especially kits, would be accounted for in every lodge, used a mean of five animals per lodge in his estimates of populations.

If we assume that the mean number of beaver per lodge within the proposed KVNM is the same as it is in interior Alaska, then four or five times 25 active lodges (Table 9) yields an estimate of 100 to 125 beaver within the KVNM. Since we undoubtedly missed seeing some active lodges, this estimate should be considered conservative.

There are no readily available data for estimating productivity of beaver within the proposed KVNM, indeed, even harvest data are not a very reliable index of the health of the population since beaver taken for

Table 9. Census of beaver dams and lodges along drainages within the proposed Kobuk Valley National Monument, summer, 1974.

Drainage	Dams	Lodges	Comments
Ahnewetut Creek	0	0	-
Elaroniluk Creek	3 (2 old)	0	-
Kallarichuk River	0	0	-
Kalliguricheark River (W. Fork)	8 (2 old)	3	-
Kalliguricheark River (E. Fork)	1	1	-
Kalliguricheark River (Main)	0	0	-
Kavet Creek	2	0	-
Kuchuk River (headwaters only)	1 (1 old)	1 (1 old)	-
Kobuk River (pond adjacent)	0	1	-
Kugarak River (headwaters only)	10	6	SE edge Waring Mountains
Mishuk Creek	21	4	-
Nakochelik Creek	9 (2 old; 2 broken)	2	-
Niaktuvik Creek	6	1	-
Nierak Creek & Unnamed Ck.	16	5	-
"OCA" Lake	1	1	-
Omaluruk Creek	1	0	-
Salmon River	0	1	-
Tetitsook Creek	0	0	-
Tunuktuk Creek	13 (6 old)	0	-
TOTALS	92 (15 old or broken)	26 (1 old)	

personal use are seldom sealed and relatively few beaver have been sold to fur buyers in recent years. Even if accurate harvest data were available, by themselves, they would not be sufficient to judge productivity of beaver since some trappers attempt to take only the larger, adult beaver thus introducing a bias in the data.

Big Game

Big game animals, along with fish, have had a long cultural and traditional history of use by residents of the Kobuk Valley. Five species, classified as big game animals by the Alaska Department of Fish and Game, are treated in this section. They include black and brown bear, wolf, moose, caribou and Dall sheep.

Bears

Both black (*Ursus americana*) and brown (*Ursus arctos*) bears are known to have existed within the Kobuk Valley throughout historical times. Traditional eskimo stories refer separately to both black and brown bears (Foote, 1966) and early nonnative travelers reported the presence of both species (e.g., Mendenhall, 1902) around the turn of the century.

There appears to be no written record of the distribution or abundance of black bear in the Kobuk Valley. Neither Scott (1949), who reported on the condition of game in the Kotzebue region in 1949, nor Woolford (n.d.), who surveyed wildlife utilization by villages on the Kobuk in 1954, mention the presence or use of black bear. In 1958-1959 Shungnak residents were reported as occasionally taking bears (Heller and Scott, n.d.) and during the mid-1960's Foote (1966) mentions that "black bears are also often seen, although the population apparently was reduced during a poor berry growing year about 1962-1963." Although biological studies, surveys and harvest data have been gathered by biologists of the Alaska Department of Fish and Game in various parts of Alaska, no data on black bears in Game Management Unit 23, within which the Kobuk Valley lies, are included in the Bear Reports or the recent Annual Reports of Survey-Inventory Activities.

During our summer field season we observed seven black bear. Except for one sow with a yearling, all others were single animals. Since they were seen at widely separated locations, and were of different sizes and/or coloration, they were probably all different animals.

In addition to direct observations, tracks were seen at many other locations within the valley both north and south of the Kobuk River. All observations and sign were at elevations below 300 m, the highest elevation sighting being on Anaktok Creek, a tributary of the Salmon River, where the sow with cub were seen on July 25, 1974.

Erickson (1965) has reported that the black bear in Alaska, as elsewhere, is a forest species but that "it has a decided preference, however, for 'open' forests rather than heavy timber." Furthermore, he states that marking studies indicate that individual black bears may spend the greater portion of their lives within 8 km of their birthplace. By combining the area of those vegetation types (types 3, 5, 7, 10, 12 and 13) identified by Racine (Table 3, PART II, this report) which might qualify as "open" forest, we arrive at a total of 1677 km^2 of potential black bear habitat within the proposed KVNM. If we assume non-overlapping uniform use of space and a radius of 8 km from birthplace for each adult bear, then the potential habitat should support 8 to 9 bears. Since we saw seven black bears and it is almost certain that we missed seeing many more, this estimate must be regarded as too low.

Kemp (1972) in Alberta and Rogers (1974) in northeastern Minnesota working with marked (tagged or radio-colored) black bears have estimated densities of approximately one bear per 2.66 and 2.76 km^2 of habitat respectively. Applying these densities to the 1677 km^2 of potential habitat within the proposed KVNM, we arrive at estimated carrying capacities of 631 or 608 bears respectively. In the Kobuk River valley, where black bears are at the northern edge of their range and the forest habitats are also at their limit, it is doubtful that black bear would even approach these densities. The true population size and carrying capacity of the proposed KVNM undoubtedly falls within these extremely wide limits of 8 to 600 bears.

Historical records of the abundance and distribution of the brown bear within the Kobuk River region are almost as scarce as they are for the black bear. Warden Grenold Collins, in his annual game report, noted that "occasionally, barren-ground Grizzlies are taken up the Noatak, Kobuk and other Arctic districts" (Dufresne, 1936) which merely indicates that brown bear were sufficiently abundant that some were harvested.

In 1961, a regulation was instituted that required hunters to submit hides of bears to the Department of Fish and Game for sealing (Erickson, 1963). This process provided information on the bears harvested primarily by sport hunters since bears taken in rural areas by local residents rarely were submitted to the Department for sealing. Harvest figures since 1961 for Game Management Unit 23, which includes the Kobuk Valley, reveal a minimum take ranging from 6 to 29 bears (Lentfer et al., 1969). These data are of very limited use since they represent primarily sport hunter harvest and, therefore, do not reflect the full yearly removal of browns from GMU 23. Year to year fluctuations in reported harvest probably do not reflect the abundance of availability of browns as much as they reflect the number of hunters interested in and capable of affording a brown bear hunt.

Dean and Chesemore (1974) examined two areas within the Kobuk drainage during their 1963 biological survey, "Redstone" Lake in the Redstone River Valley and Walker Lake near the headwaters of the Kobuk River. They make no mention of seeing browns or their sign in the vicinity of "Redstone" Lake but found that "at Walker Lake, there was little grizzly sign."

During the summer of 1974, we saw single brown bears on four occasions: on July 25 on the north side of a peak above Anaktok Creek; on July 31 on a side channel of the Salmon River about 1.6 km above the mouth of the Kitlik River; on August 20 on the mountains above the upper Akillik River; and on August 23 south of the Jade Mountains in the area of the 1971 fire. In addition to these direct observations, fresh tracks were observed at six locations along the Salmon River and on several of its tributaries including the lower Anaktok Creek, upper and lower Sheep Creek, and lower Nikok Creek. Fresh tracks were also seen near the Hunt River-Akillik River confluence and on the Akillik River above the mouth of Nekakte Creek. We found no evidence of browns along the Kobuk River or in the area south of it.

The sightings and sign we recorded are not sufficient to allow us to make a population estimate of brown bear within the proposed KVNM. Recent studies of marked brown bear in the central (Crook, 1971) and eastern (Curatolo and Moore, 1975; Quimby, 1974; Reynolds, 1976) Brooks Range provide some guidelines for making rough estimates of the number of bears that might inhabit the proposed KVNM. In the Canning River drainage, Quimby (1974) estimated the density of brown bears as one bear per 119 km^2 but Curatolo and Moore (1975) considered his study area to represent high quality bear habitat whereas in their study, which included a wide range of habitat quality, the density was one bear per 148 km^2. Crook (1971), whose study area included more of the poor quality coastal plain habitat, estimated one bear per 285 km^2. Although brown bears seem to prefer grassy meadows and open tundra habitats, they are found in other habitats as well (ADF&G, 1973) and the bears and sign we observed included both open and forested habitats. Therefore, if we apply the three estimates of density mentioned above to the total area of the proposed KVNM (Racine, PART II, this report, Table 3), the number of bears present could range from as few as 26 to as many as 63. Since the proposed KVNM does not contain a great deal of high quality brown bear habitat, the best estimate would probably lie somewhere between these two, but closer to the lower figure.

Productivity of northern (eastern Brooks Range) brown bear populations is low compared to populations further south (Alaska Range and southern coastal areas) and appears to be due to: comparatively old age at first breeding (8.5 to 9.5 years); relatively long breeding interval (4 or possibly 5 years); small litter size (1.6 to 1.8) and a high mortality rate of young solitary bears (Curatolo and Moore, 1975; Quimby, 1974; Reynolds, 1976).

Wolf

Wolves probably inhabited the Kobuk Valley long before written historical accounts, however, Stoney (1900) was the first to specifically mention them. He described a technique of caching food in the ground to protect it from wolves that were apparently abundant enough to be a

nuisance to the native caches. Joseph Grinnell (1901), who camped near the mouth of the Hunt River during the gold rush of 1898, mentions that a native trapped a "big gray wolf" in early November. Although Mendenhall (1902) does not specifically mention wolves, presumably the wolves were still present in the Kobuk region.

Fred M. Sickler (1917), the Bureau of Education school teacher at Shungnak reported that wolves raided the reindeer herd (then numbering approximately 600 animals), once in spring and once in fall of 1916.

According to Smith (Smith and Mertie, 1930) wolves were very scarce in the vicinity of the Kobuk, Upper Noatak and Alatna Rivers, and in 1926 "... a wolf is said to have been killed in the upper part of the Noatak valley...". This corresponded to an apparent decrease in wolf population throughout that part of northern Alaska along the Yukon and upper Koyukuk River (Murie, 1944) although there are no reports about Arctic wolf abundance.

In the 1930's conflicts between the burgeoning reindeer industry and wolves in northwestern Alaska began to receive attention. In 1936, the Alaska Game Commission stated that "Great concern is being expressed in all parts of the territory over the alarming increase of wolves and coyotes. Wolves in particular have become so numerous as to threaten the very existence of the reindeer industry on the Arctic Slope" (Alaska Game Commission, [1936]).

In a letter to the Alaska Game Commission, Archie Ferguson wrote that "the wolf situation in this country is getting serious. The natives believe that over one thousand deer are killed now..." (Dufresne, [1936]). Although he lived in Selawik at the time, Mr. Ferguson was referring to the Selawik-Kobuk region. In the same year, Frank Stoker of Noatak wrote that the wolves were increasing fast, and that the Natives reported packs of up to twelve animals, causing the loss of thousands of deer and caribou (ibid).

In the mid 1930's, the Territorial bounty on wolves was increased from $15 to $20 and wolf pelts began to have greater cash value on the fur market (Anon, 1935). One result of this was more intensive concentration on wolf trapping by many inland Eskimo groups, such as the Nunamiut of Anaktuvuk Pass (Robert Stephenson, ADF&G, Fairbanks, pers. comm.). Apparently, the Kobuk Eskimos also were trapping in earnest as the following note in the September, 1944 Alaska Sportsman Magazine mentions: "Migratory Eskimo hunters of the Arctic rim north of the Kobuk River brought the pelts of one hundred and three wolves into Shungnak to claim bounty. These hunters derive an average income of a thousand dollars a year from wolf hunting" (Anon, 1944).

The real or imagined threat by wolves to the domestic reindeer herds and wild game populations in Alaska led to the assignment of personnel from the U.S. Fish and Wildlife Service's Predation and Rodent Control

branch to Alaska in 1948. In the early 1950's, PARC field men began an active campaign of aerial gunning and poisoning around the Arctic caribou herd and near reindeer ranges, including the Noatak River. In 1949, Assistant District Agent Patrick made several wolf control flights along the Kobuk and Noatak Rivers, and took a total of 20 wolves in the Kobuk-Noatak-Kotzebue area (USFWS, 1950). In 1950, "wolf-getter" stations (cyanide pellets propelled by an explosive charge) were placed on the Noatak, and 21 wolves were taken (USFWS, 1951). These "getter" lines, together with aerial gunning, were continued for several years in order to establish a "wolf-free" buffer zone between the reindeer ranges in the Kotzebue area, and the Arctic caribou herd to the east and north (USFWS, 1959). The PARC agents found a direct correlation between the presence of the Arctic caribou herd and wolf density -- when the herd wintered in the Noatak-Kobuk area, wolf densities, and the number of wolves taken in wolf control operations, increased, as did predation on the reindeer. PARC further felt that these wolves followed the caribou herds out of these areas and onto the North Slope. In the spring of 1952, aerial gunning teams shot and poisoned 259 wolves around a caribou concentration at Umiat. This same concentration wintered near Kotzebue on the Noatak, and PARC men took 200 more wolves in early 1953. This was the last major campaign against wolves on the North Slope by PARC personnel, however aerial bounty hunters and native trappers continued to take wolves. PARC field operations were restricted to some aerial gunning and poisoning in the Noatak-Kobuk area. By 1955, PARC reported that over 1000 wolves had been taken by Service personnel alone from the western Arctic caribou herd since 1952, yet the take of 200 or so wolves in the Noatak area remained the same (USFWS, 1955).

Native hunters were accounting for only about 20% of the total wolf harvest during this period (USFWS, 1953). Woolford (n.d.) reported that wolves were primarily being taken incidentally to caribou hunting and that a total of 23 wolves were taken by the upper and middle Kobuk. Shield Downey of Ambler (pers. comm.) said that the Kobuk Eskimos did not do much hunting for wolf pups in the summer for bounty, and that most of the wolves were taken by government hunters.

During the late 1950's and early 1960's, Arctic wolf populations declined, and few wolves were found in the Noatak area (USFWS, 1957, 1961, 1962). During this period, formal wolf control operations were limited to encompass only the major reindeer ranges near Kotzebue and the Seward Peninsula. By 1965, PARC had been phased out entirely and no wolf control work was being conducted. However, bounty records indicate that in 1961-1962, 113 wolves were taken along the Kobuk River, a dramatic increase from the less than twenty per year for the previous two years (Rausch and Winter, 1964).

Wolf harvest records and population status for the period between 1962 and 1971 are unavailable. In 1971, a program of sealing wolf and wolverine hides was initiated by ADF&G. All persons trapping or hunting wolves and wolverines who presented hides for sealing were required to fill out

sealing forms on which they noted the method of harvest, number of wolves seen in the pack, and location of harvest. Sealing records should be interpreted as minimum harvest figures because many wolf hides are utilized locally for such items as parka ruffs and trim, and mukluks. Wolf hides utilized in this fashion are seldom sealed. The 1972 and 1973 sealing records indicate that the total take of wolves in the Kobuk Valley was 18 and 19 respectively. The total number of wolves seen with those taken was 37 in each year.

The harvest figures, while giving an index of winter abundance, do not necessarily reflect the abundance of wolves in the summer. A large portion of the Kobuk wolves apparently follow the migrating caribou out of the valley onto the North Slope (Kelly, 1954), a situation similar to that reported about the barren-grounds of Canada (Kuyt, 1972). The remainder of the wolves are probably associated with dens in the Kobuk Valley, representing the stable portion of the wolf population. There were 10 direct observations of wolves by the field party in 1974. Of these, 6 were in the upper Salmon-Tutuksuk area (3 adults and 3 pups of the year), one was on the lower Salmon River, and 3 were seen near the Waring Mountains southeast of Kiana. An additional observation by a USGS field crew earlier in the summer indicated that 4 adults and 5 young pups were in the vicinity of the upper Hunt River. Wolf tracks subjectively determined to be less than a week old were also noted and may roughly indicate abundance. On the trip downriver between 20-23 July, 9 tracks of one animal and 3 tracks of pairs of animals were found. These tracks were scattered over virtually every stop the field party made, and especially where stops were near each other, could have been made by the same animal or animals. Tracks were only considered as "pairs" if they were of recognizably distinct size and similar age, or if other evidence warranted including them as two animals travelling together. On the trip down the Salmon River, fresh tracks of only a single animal and 2 pairs were found; and these were primarily on the upper part of the river. On the return to Ambler, between 3-8 August, 5 single wolf tracks and 1 set of 3 animals were found. The set of three tracks was found near an area from which the field party had heard howling earlier that day. At the Kobuk dunes, one set of single tracks and 2 sets of pairs were seen. All of the above tracks were those of adults. The difference between the number of tracks seen on the return upriver, even though many stops were duplicated in addition to the new areas covered, suggested that the wolves were not utilizing the area along the river as heavily as earlier in the year. This could have been an isolated phenomenon caused by the recent flooding, or could be a "normal" shift in summer movements.

Winter wolf density, based on the sealing forms, is 1 wolf/310 km^2. It should be emphasized again that this is an extremely conservative figure because only those wolves seen accompanying an animal which was harvested were reported on the forms, and because of the unreported kill utilized locally. The summer wolf density, based on 19 direct observations and a figure of 15 for the number of nonreplicated tracks, was approximately one wolf/336 km^2. The total of tracks was based on the following assump-

tion: (a) the wolves observed in the upper Salmon-Tutuksuk area probably would not frequent the bars of the Kobuk River, but could have made the tracks seen along the Salmon River, (b) the tracks seen at the Kobuk dunes were not counted on the trip from Kiana to Ambler, (c) tracks of a single animal found on a stop within several river miles of tracks of a pair represented distinct groups of animals, and (d) tracks found more than 10 river miles apart represent distinct individuals. Although these wolf densities are lower than those for other areas of Arctic North America, (see Stephenson and Johnson, 1973, for North Slope estimates; Kuyt, 1972 for a discussion of the Canadian barren-grounds wolf densities; and Clark, 1971 for wolf densities on Baffin Island), it is our subjective opinion that the wolf population in the Kobuk Valley is much greater than indicated by the density estimates given above. These density figures should be interpreted as an absolute minimum.

The approximate location of three dens was determined from extrapolation from the two direct observations of pups, and from a conversation with Merril Merino of Ambler who mentioned that he thought there was a wolf den along the river somewhere between Ambler and the Hunt River. These dens appear to be between 40 and 65 km apart, similar to the range of distance between dens reported by Stephenson (1974) for the North Slope. Stephenson (1974) concluded that for North Slope dens the following were among the important characteristics: (a) moderately steep, southern exposure, (b) well-drained soil, and (c) proximity (usually within 1 km) to water. These requirements, in addition to spruce and birch windfalls, do not seem to be lacking in the Kobuk area. Certainly a scarcity of suitable den sites is not a limiting factor to the wolf population of the Kobuk.

Since no direct observation of wolf kills were made, all information concerning wolf food habits is based on 25 adult scats collected at stops along the trip. Most of these scats were collected along the Salmon River, a few were collected upriver from the Hunt River, a few at the Kobuk Dunes, and a few along the Kobuk River. It was impossible to determine the actual age of the scats, so this is a further bias to the sample. No pup scats were found. Caribou adults were the predominate prey item (84%) in the scats; many of these scats contained caribou winter hair, although at least two contained summer hair. The field crew found several bull caribou heads, with antlers intact and not in velvet, on the east side of the upper Salmon River. Because it is doubtful that the Eskimos get that far up in winter, these were probably wolf kills. Several scattered skeletons of either winter-killed or wolf-killed caribou were also found by the field party on the west side of the upper Salmon River. The only scats containing caribou calf hair were found in the upper Salmon River area. The frequency of caribou in the Kobuk wolf scats is similar to the frequency in which caribou occurred in the wolf scats on the Canadian barren-grounds and the forest margin (data from Kuyt, 1972).

Only one scat contained moose hair, but this scat was found near a moose carcass. The moose appeared to have fallen through the ice, or

died in some other accident; it did not appear to be a wolf kill. This low incidence of moose remains in scats is noteworthy because moose sign was found along the entire river, and as far as the head of the Salmon. Shed moose antlers as far as Anaktok Creek on the upper Salmon suggest that moose winter that far up. However, Stephenson and Sexton (1974) report that wolves in the Central Brooks Range take more moose in years of low winter caribou density, so it is possible that wolves are not yet taking a significant number of moose in the Kobuk because of the availability of caribou.

Snowshoe hare remains were found in 34% of the scats. Stephenson (pers. comm.) has found that hares and other small mammals can comprise a major portion of the diet, particularly in the summer, during periods when these animals are at high densities. The field crew did not determine abundance of small mammals during the past year, and there were conflicting reports from the natives interviewed. The small percentage of microtines in the scats, particularly those of the upper Salmon, is surprising. Shideler watched a white wolf "mouse" in a meadow near Anaktok Creek -- the wolf pounced twice within a minute, each time catching and eating a microtine (*Lemmus*?). It is likely that the situation in the Kobuk Valley is similar to other areas of Alaska in that small mammal populations fluctuate widely due to local conditions within the same general area. Murie (1944) described wolves hunting small mammals even when caribou were abundant. Stephenson (pers. comm.) has found that scats collected from some den sites in the foothills of the Brooks Range contained as much as 70% microtines for both pups and adults, indicating that under certain conditions, wolves can survive and raise young on a small mammal diet.

Kuyt (1972) calculated that for normal activities, a wolf would require approximately 7 pounds of meat daily, although the figure would be somewhat higher in winter and lower in summer. He also figured that, based on the breakdown of wolf kills according to age classes, that this would be a total of 23 caribou/year comprised of 5 calves, 2 yearlings, and 16 caribou over 2 years of age. Based on nutritional requirements for dogs given by Catcott (1968), a lactating wolf would require approximately 10 pounds of meat/day during the first few weeks of lactation (30-50 days, depending on the age of the bitch). Kuyt (1972) also found that, after weaning, growing required more than 1/2 the adult requirement (or more than 3-1/2 pounds/day) until 4 months of age, at which time they essentially required the same amount of meat as an adult wolf. These computations, based on work with captive wolves and domestic dogs, should be interpreted as very rough guidelines due to the type of extrapolation required, and to the fact that Kuyt did not include the effect of small mammals in the diet of the wolves he studied.

The important features emerging from this review are:

(1) In spite of the scarcity of historical information, there is little doubt that wolves have been present in the Kobuk Valley for the

past century, and there is no reason to doubt that they were present long before that. The abundance of wolves has fluctuated widely over that period, possibly in response to prey fluctuation, especially caribou, or to the effects of rabies, distemper, or mange. Unfortunately virtually no information is available concerning the cause for these fluctuations.

(2) There appears to be a stable segment of the wolf population, presumably those animals associated with dens, that remain in the valley year-round. During the periods of caribou migration into and out of the valley, and while the caribou remain in the valley in winter, a large increase in "transient" wolves occurs. These are probably young wolves, based on data gathered by Stephenson (Stephenson and Johnson, 1973) in the central Brooks Range, and Kuyt (1972) on the Canadian barren-grounds.

(3) At current reported harvest levels, trapping and ground shooting accounts for approximately 20 animals a year, although there is an undetermined nonreported kill. Local utilization probably accounts for most of the unreported kill.

(4) A minumum density of 1 wolf/310-336 km^2 exists in the Kobuk Valley. Although this figure is among the lowest for Arctic North America, the subjective feeling of the 1974 field party is that wolves are much more abundant than the density figure indicates. Wolves do not appear to be rare along the Kobuk, and current harvest levels do not appear to threaten the population, especially considering that the harvest occurs at the same time that wolf populations are the densest. It is likely that much of the harvest represents young transient wolves and therefore current harvest may represent a form of "compensatory mortality".

Moose

There is evidence that changing climatic patterns have caused the northern limit of moose in Alaska to advance and withdraw, perhaps several times, since the Pleistocene (Melchior, in press). Fossil remains (Hall, 1973; Larsen, 1968), glacial history (Hamilton, 1973, 1974) analyses of climatic trends (Hamilton, 1965; Hopkins, 1972; Melchior, PART I, this report) and a paleoecological study of the Onion Portage area of the Kobuk River by Schweger[2] all show that alternating cold and warm periods have characterized the climate of northern and northwestern Alaska since the Pleistocene. Forest extensions occurred during some of the warming trends, and beaver followed these extensions into the western part of the Seward Peninsula (McCulloch, 1967). LeResche _et al_. (1974) concluded that warming

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[2]Schweger, C. E. (in draft). Late Quaternary paleoecology of the Onion Portage region, northwestern Alaska. Ph.D. Thesis, Univ. Alberta, Edmonton, Alberta, Canada.

trends would have been conductive to improved habitat condition for moose, as well as beaver, and that moose probably extended their range northward during warm periods but retreated during cold periods and glacial advances.

Moose were apparently scarce or absent in the Kobuk Valley during the late 1800's and early 1900's. Stoney (1900) made no mention of moose during his travels in the Kobuk country in 1883 to 1885. Grinnell (1901) spent the winter of 1899 on the Kobuk near the mouth of Hunt River, and he made no mention of moose. Mendenhall (1902) reported moose to be scarce everywhere he travelled and entirely absent from the upper Kobuk. Charlie Lee, a long-time resident in the valley, told Dick Nelson that the first moose appeared in the Kobuk Valley in 1910 (pers. comm.).

Smith and Mertie (1930) state that moose were once very common in the Kobuk area, but that in the 1920's they were extremely scarce. The source of their information is unknown.

A review of the literature shows little information on Kobuk moose populations from the 1920's to the late 1950's. According to residents of Shunguak interviewed in 1958-1960, moose had never been present in large numbers in the upper Kobuk area - 4 to 5 being the largest number taken in a year (Heller and Scott, n.d.). Aerial surveys flown by biologists of the Alaska Department of Fish and Game in 1959 and subsequent years indicate that moose were distributed throughout the Kobuk Valley and Baird Mountains. Populations were low over most of the region, but in some areas they reached moderate abundance. The moose were found mainly in the major Kobuk Valley (Harbo, 1960; Rausch, 1971; State of Alaska, 1973). Dean and Chesemore (1974) reported seeing moose at each of their camps during their 1963 survey of the Baird and Schwatka Mountains.

Moose have been hunted in the Kobuk Valley at least since their apparent re-establishment in this region in the early 1900's. There are no data on harvests until 1960, however. There was some concern that hunting controlled moose numbers and kept them from increasing or from expanding their range (Rausch, 1971). Harbo (1960) reported that although moose hunting in Game Management Unit 23 (which covers all of the Kobuk, Noatak and Selawik River drainages) had been closed for several years prior to 1960, there was still substantial hunting pressure. Native subsistence hunters probably killed 90 to 100 moose along the Kobuk River each year. Hunting was probably opportunistic, and both sexes were taken. Because neither the size of the moose population nor the size and composition of the illegal harvest were known, the effect of hunting was difficult to assess. Harbo (1960) found a sex ration of 79 bulls:100 cows in an aerial survey of Kobuk Valley moose. Although sex ratios near unity usually denote limited hunting pressure (prior to statehood, cow moose hunting was illegal in all areas), Harbo speculated that subsistance hunting of either sex could maintain equal sex ratios while severely cropping the population.

Rausch (1971) reported on a second aerial survey of Kobuk River moose flown by Bob Peqau on December 5 and 6, 1968. Of 51 moose counted on the Kobuk River and the Squirrel River, the ratios were 67 bulls:100 cows and 46 calves:100 cows or 28 calves per 100 adults. The herd composition was 31.4 bulls, 47.1 cows, and 21.6 calves. Rausch noted that the sample size was very small, and that the composition data derived from it might not accurately represent the population. The moose population did not seem dense compared to populations in interior and southcentral Alaska.

The distribution of our summer observations of moose would amount to an itinerary of our travels through the study area. That is, we encountered fresh moose sign -- tracks and droppings -- or saw moose virtually everywhere we travelled. We actually saw 28 moose, and most of these were within one mile of the Kobuk River or along the lower reaches of major tributary streams. We also saw moose near the heads of some of the smaller creeks and rivers, well above treeline (e.g., Salmon River and Sheep Creek). There was abundant moose sign on the Great Kobuk Sand Dunes, and we saw a bull moose at "OCA" Lake in the Baird Mountains. Occasionally we spotted moose in open tiaga areas away from major watercourses. In summary, we saw moose throughout the proposal area, except in the highest and roughest mountain regions. There was some indication, however, that moose preferred valley bottom areas along watercourses.

Of the 26 moose that we observed and classified during the summer, 38% were bulls, 42% cows, and 19% calves. This represents ratios of 91 bulls:100 cows; 45 calves:100 cows; and 24 calves:100 adults. This sample is very small and, therefore, may not accurately represent the true ratios.

Aeirial surveys flown while there is snow on the ground offer a better opportunity to visually pick out moose than summer observations. Even under winter conditions, however, moose lying in spruce woods or among tall willows are difficult to see. Consequently winter surveys, although generally more accurate than summer ones, still represent a conservative estimate of total numbers present.

In cooperation with John W. Coady of the Alaska Department of Fish and Game, an aerial survey was made of the Kobuk River from Walker Lake, near the headwaters of the Kobuk, to and including the lower portion of the Squirrel River on March 13 and 14, 1975. Two other northern rivers, the Anaktuvuk and Chandler, and a portion of the Coville River were also flown the day before, March 12, 1975. The results of these surveys are given in Table 10. Since bulls are antlerless in March, it is difficult to distinguish bulls from cows, especially from the air at the minimum flight speed of a Cessna 180. Thus, the only distinction attempted was between adults and calves.

The number of animals listed for any river or segment of a river represents the minimum number present since some animals were almost certainly missed by the survey. The animals in a group varied from one to ten but the mean group size ranged from 2 to 3. The most striking feature

Table 10. Location and statistics from aerial surveys of moose made in March, 1975.

Location	No. Animals	No. of Groups	Mean Group Size	Maximum Group Size	No. Calves	No. Adults	Calves Per 100 Adults	Calves % in Herd
Anaktuvuk River	75	26	2.88	10 Ad.	3	72	4.2	4
Colville River (mouth of Anaktuvuk to Umiat)	46	19	2.42	6 Ad.	5	41	12.2	11
Chandler River	100	46	2.17	6 Ad.	8	92	8.7	8
Kobuk River Drainage:								
Walker Lake to Shungnak	74	-	-	-	8	66	12.1	11
Shungnak to Ambler	30	14	2.14	4	4	26	15.4	13
Ambler to Kiana (KVNM)	79	34	2.32	7	17	62	27.4	22
Squirrel River	42	23	1.83	4	5	37	13.5	12
TOTAL Kobuk River	225	-	-	-	34	191	-	-

of the data in Table 10 is the relatively high proportion of calves present within the KVNM segment of the Kobuk River (21.5 calves per 100 adults) compared to other segments and other rivers. Calves in this segment represented 22% of the herd, a percentage slightly higher than our summer figure (19%). However, when the other segments along the main Kobuk River and the Squirrel River are added together, calf production appears lower. Calves then represent only 15.1% of the herd, a drop from the 1968 estimate of 21.6% and less than our summer estimate for the KVNM area. The sample sizes of these surveys were fairly small and therefore subject to considerable error, but _if_ these estimates are near the truth, then the data may be showing that the portion of the Kobuk Valley that passes through the KVNM is better for calf production/survival than other portions of the river. Additional, more intensive study is needed to ascertain if this is true.

Accurate data on moose mortality in the Kobuk Valley are lacking. The reported legal harvest in Game Management Unit 23, which includes the Kobuk River, has ranged from 34 to 77 moose during the period 1963 through 1968, but the actual kill may have been 100 to 150 (State of Alaska, 1973). The unreported harvest is probably mostly subsistence kill; harvest reporting from rural areas of Alaska is usually incomplete. There are no data on kills by predators (primarily wolves). As a consequence of our poor knowledge of moose mortality, it is not possible to estimate net production for moose inhabiting the Kobuk Valley. All recent reports, however, indicate that moose in northwestern Alaska are expanding in numbers and range (Le Resche _et al_., 1974; State of Alaska, 1973).

Caribou

The historical distribution of caribou in Alaska and, more narrowly, northwestern Alaska, have been reviewed by Lent (1966), Skoog (1968), Hemming (1971) and others. Both the numbers of caribou and the range occupied by them have varied considerably during the past 100 years. The review that follows concentrates on the changes that have occurred in and adjacent to the Kobuk Valley but it must be remembered that these local changes are a reflection of changes that have occurred over a broader geographic area.

Cantwell (1887) was the first white explorer to mention the abundance of caribou (which he called "deer") in the Kobuk region. He reported that "...the natives inform us that those animals (caribou) were very plentiful in the mountains in this region." Cantwell also mentioned that the deer migrate to the northeast in winter. However, C. H. Townsend, a natural historian with the Cantwell party, differed with the native reports when he stated that "the wild Alaskan variety of reindeer is probably not very numerous in the Kowak Region, although Mr. Cantwell saw a few small herds among the hills at the headwaters of the river." Mr. Townsend also alluded to the scarcity of tracks in the lower river during the month of July.

Stoney (1900) stated that most of the deer came from the Noatak Valley rather than from the Putnam (Kobuk) Valley. Stoney's travels took him to the headwaters of the Alatna, Noatak, and Killik Rivers, and out onto the North Slope. He specifically mentioned that on 9 December 1886, he reached a settlement on the upper Noatak where 30 people had approximately 2000 pounds of caribou meat. Some of the caches had 30 caribou in them, and on the day of Stoney's arrival, the natives had killed 13 "deer". In winter, the Kobuk people often visited the "Arctic People" (Nunamiut) who lived from the upper Noatak to Chandler Lake (Stoney, 1900).

Grinnell (1901) spent the winter of 1898-1899 on the Kobuk River, camped near the mouth of the Hunt River. Although he made fairly extensive wildlife observations, he did not mention that caribou were plentiful, but he did state that the miners traded for deer meat (rather than hunting for their own).

By interviewing older Kobukmiut, Giddings (1961) and Foote (1966) found that during the period around the turn of the century, the men would hunt caribou and sheep in the mountains bordering the Noatak during the summer, returning to the Kobuk River in the fall. Such a summer movement of hunters suggests that the caribou were not plentiful along the Kobuk during the winter. According to Foote (1966), caribou were common along the river in the winter until the late 19th century, then began to decline throughout northwestern Alaska. Caribou had disappeared from Norton Sound-Seward Peninsula region somewhat earlier (Lent, 1966; Skoog, 1968; Melchior, 1974a). Several photographs in Stoney (1900) and Grinnell (1901) imply that reindeer skins, presumably obtained in trade from Siberian Eskimos, were commonly used for clothing. The implications of these sources of information are that caribou were probably common at least in the mountains bordering the Kobuk Valley on the north, but that caribou winter distribution around the turn of the century may not have included the Kobuk Valley.

Mendenhall (1902), who canoed the Kobuk River in the summer of 1901, reported that "there are caribou in the region about the Kanuti River, and herds are occasionally reported on the hills between the upper Kowak (= Kobuk) and the Koyukuk, but the Kowak natives now are generally forced to cross over to the Noatak Basin, or eastward to the head of the Totsenbet River, in order to secure caribou skins for clothing."

The general and widespread decline in caribou (through mortality and/or emigration) that occurred in western Alaska during the latter half of the 19th and early part of the 20th centuries provided the major stimulus for the introduction of reindeer from Siberia in 1891-1892 (Melchior, 1974a, 1974b). The initial mainland introduction took place near present day Port Clarence on the Seward Peninsula (Jackson, 1894) but by 1913 there were 754 reindeer in the vicinity of Shungnak (Jones, 1913 as cited in Foote, 1966). Reindeer remained in this area until the early 1940's when they disappeared (Foote, 1966).

Caribou were absent or rare from the Kobuk Valley and the northwestern coastal region of Alaska until the mid 1920's. Reindeer herders living northeast of Kotzebue have said that they did not see caribou in the area until 1924 (Dr. Sam Harbo, University of Alaska, Fairbanks, pers. comm.). By the mid-1930's caribou were at least on occasion, abundant in the northwest. In December 1936, a huge herd of caribou (estimated at 90,000 animals) was sighted on the Cutler River, which drains into the upper Noatak (see Skoog, 1968, p. 248) and caribou were reported as mingling with reindeer herds all along the coast from Nome to Pt. Barrow (Dufresne, 1937).

Up through 1946, caribou traveled at least as far south as the Selawik River (Scott, 1950) but between then and 1952, they were not present that far south (Scott, 1954) and instead, apparently wintered further north in the Noatak and sometimes the Kobuk Valleys (Scott, 1949, 1950, 1952, 1953). This change in movement and range was not, apparently, due to any decline in the number of caribou. In April, 1947 in the Kobuk vicinity, it was reported that "thousands of caribou were killed this year" (Gillham, 1947), and in December, 1947 Sig Wein is reported to have seen "a line of moving animals (caribou) which were from one to twenty caribou in width and about 75 miles long. This means that somewhere between a quarter and a half a million animals could have been on the move. The herd was seen from the air north of the Baird Mountains and probably between the Baird and the De Long Mountain Range in the valley of the Noatak" (Hynes, 1948). At this same time, smaller bands were observed northeast of Shungnak, in the Kobuk Valley. Caribou again returned to the Selawik River area in the fall and winter of 1952-1953 and 1953-1954 (Scott, 1954). Animals must have passed through the Kobuk Valley, however, since Woolford (n.d.) found that the combined native harvest of caribou for 1954 had been 1075 animals for Kobuk, Shungnak and Kiana (Ambler did not exist then). Of this number only 25 were taken by Kobuk but 800 were recorded for Kiana.

During November and December, 1955 a herd estimated at 20,000 animals moved south and west of the Kobuk-Noatak region "to the head of the Buckland River ranging as far west (sic, should be east) as the head of the Huslia River. Other segments spread out through the Waring Mountains, south of the Kobuk River, across the Selawik Flats, and up the Selawik River more than 50 miles" (Olson, 1957). The caribou remained in this area through March and into April, 1956 when they moved north. On April 6-7, 1956 an estimated 1,500 were observed between Kiana and Shungnak and on April 19, 1956 a minimum estimate of 5,000 were seen between the Squirrel and Salmon Rivers. On May 3, 10,000 plus animals were seen in the Ambler, Cutler and Noatak areas. Pilots flying out of Kotzebue reported that caribou were not seen in this area for the remainder of 1956; other observers saw large numbers north of the Brooks Range in the fall and winter (Olson, 1957).

Caribou were not seen south of the Brooks Range during the winter of 1956-1957 but on July 12, 1957 John Cross, a Wein pilot, saw a large number of caribou moving south at the head of the Noatak River and by late fall

and early winter, 1957 there were small groups scattered throughout the Kobuk-Noatak drainages (Olson, 1958). According to Cross, several thousand moved across the Kobuk Valley into the Waring Mountains in early November (ibid).

During January, 1957 residents of Kobuk and Shungnak reported many caribou immediately north of their villages. In early March, Olson (1959) saw 2,000 or more animals on the upper Kobuk Valley but no caribou were found west of the head of the Selawik River (about 45 km southeast of Kobuk). Another 4,000 caribou were observed in the Noatak Valley between the Kelly and Cutler Rivers (ibid). In late May and early June caribou moved toward the upper Colville and Utukok Rivers but by July, many animals were back in the upper Noatak Valley between the Nimiuktuk River and Howard Pass; large numbers remained in this area during August and September (ibid). In late September, caribou began moving east out of the Noatak drainage but 50,000 or more were reported moving up the Noatak through the mountains onto the drainage north of the Kobuk River on September 28 (ibid). Another observer, however, saw many thousands in the mountains between the head of the Ambler River and Walker Lake, October 1-20 (ibid). By November small herds were spread throughout the Baird Mountains; 3,000 were seen moving down the Ambler and Sungnak Rivers on November 11 and 1,000 were recorded ranging along the Salmon River east of Kiana on November 12 (ibid). Based upon these observations, it is clear that caribou were abundant in western Arctic Alaska from the mid-1930's through the 1950's but that group size and distribution in the Kobuk region within and between years was highly variable.

During the early 1960's an intensive study was made of the western Arctic caribou population, estimated to number between 175,000 and 200,000 animals (Lent, 1966). The variable nature of caribou distribution and movements continued. The fall movement in both 1960 and 1961 passed down the south-flowing tributaries of the Kobuk River, including the Salmon and Hunt Rivers within the boundaries of the proposed KVNM. Mid-winter (early February) counts showed that in 1961, 2,400 caribou were located just west of the Hunt River and another 3,000 were located between the Kobuk River and the Waring Mountains; in 1962 no animals were observed wintering within the proposed KVNM at the time of the mid-winter survey (Lent, 1966; Fig 9).

Heavy snowfall during the spring of 1962 appeared to delay the northward movement to the calving grounds and some cows dropped their calves en route (Skoog, 1963). The calf:cow ratio for July 1962 was 53:100, down from 73:100 in 1960; barren cows and still-births were common on the calving grounds and it was thought that these problems might be associated with an increase in the incidence of the disease brucellosis (ibid).

In 1964, poor animal condition, presence of brucellosis, and difficulties at time of calving, including abortion in late pregnancy and abnormal retention of placenta, were similar to conditions noted in 1963 (Lentfer, 1965). During the winter of 1963-1964 caribou wintered further south and

east than they had for several years but large numbers also wintered in the lower Noatak and Kobuk drainages; during the winter of 1964-1965 caribou were not available to hunters of the lower Kobuk River, the animals having crossed the Kobuk Valley via the Ambler River and further east (ibid).

The percentage of brucellosis in the Arctic herd had declined by 1965 and animals appeared to be in better condition (McGowan, 1966). A large segment of the herd wintered in the headwaters of the Kobuk River; a small number wintered near the mouth of the Kobuk in the vicinity of Kiana and Selawik villages (ibid). In the spring of 1965, a small number of cows calved in the Schwatka Mountains rather than further north with the main herd (ibid).

During the winter of 1965-1966, the majority of caribou wintered in the Pah River flats and the headwaters of the Selawik River (Kiana villagers hunted in the latter area indicating no animals wintered on the lower Kobuk River), but during the spring northward movement, caribou passed near most of the villages on the Kobuk River (Glenn, 1967).

One of the four major wintering areas in 1966-1967 was south of the Kobuk River to the headwaters of the Selawik River; the spring migration passed through the Baird and Schwatka Mountains (Hemming and Glenn, 1968). Animals examined in November, 1967 were in excellent condition and the incidence of brucellosis within the herd was low (ibid).

As in the previous winter, caribou were concentrated from the middle Kobuk River south to the headwaters of the Selawik River in 1967-1968 and a large portion of the herd during the spring northward migration moved up the Ambler River (Hemming and Glenn, 1969). Weather conditions were severe throughout the calving period, however, resulting in greater calf mortality than in previous years (ibid).

The main caribou wintering areas in 1968-1969 were between Selawik and Allakaket but included the upper Pah River valley (a tributary of the upper Kobuk) and the Waring Mountains (Hemming and Pegau, 1970). During the spring migration, a major portion of this winter herd passed through the Hunt River Valley to the Cutler River drainage (ibid). By November, 1969 caribou had moved south of the Kobuk River to winter ranges.

From the observations made during the 1960's, it is clear that although caribou wintered south of the Kobuk River each year, the numbers and pathways by which they crossed the Kobuk Valley were highly variable as were the areas of winter concentration. Timing of passage across the valley also varied and seemed to be strongly influenced by weather conditions (a warm fall, untimely breakup, heavy snow, etc.), which are both variable and unpredictable in the Kobuk region (Melchior, PART I, this report).

During the summer of 1970, a census of the Arctic herd revealed a minimum population of 242,000 animals (Hemming, 1971; Pegau and Hemming, 1972), but by 1973-1974 there were signs of a decline in the population (Grauvogel and Pegau, 1976).

In the summer of 1975 a photo-census, similar to the one conducted in 1970, was attempted but was considered unsuccessful because the caribou never formed the "typical" post-calving aggregation that the sampling technique requires (Davis, Grauvogel and Reynolds, 1976). Even so, by combining information from the summer census with a herd composition count made in October (when groups tend to be homogeneous with respect to bulls, cows, yearlings and calves), a range of population estimates were calculated and all of them, including the most optimistic estimate, showed that the population had at least 100,000 to 140,000 fewer animals than the minimum count made in 1970 (ibid). This evidence of a major decline in the Arctic caribou population provided the stimulus for the most intensive survey of the Western Arctic Herd ever undertaken (Anon., 1976). The result of this survey indicated that as of July 1, 1976 adult population of the Western Arctic Herd was about 38,000 animals (26,200 cows, 8,100 bulls, 3,700 yearlings) and since there were 54 calves/100 cows, there were an estimated 14,159 calves present (ibid). All together then, a total population of about 52,207 animals were present within the range of the Western Arctic Herd at mid-summer, 1976 (ibid).

Although it is now very clear that the Western Arctic Herd underwent a drastic decline in numbers during the 1970's, one of the few predictable features of this herd, the unpredictable manner in which it utilizes portions of its range, has continued. For example, in 1974 most of the caribou crossed the Kobuk River near Ambler and wintered in the area between Rabbit Mountain and the Waring Mountains (Grauvogel and Pegau, 1976). This pathway together with a light snowfall in early winter 1974-1975, preventing easy access, resulted in a harvest for Ambler that was above normal but Shungnak and Kobuk experienced below normal harvests (ibid). In 1975, the majority of caribou moved down along the coast to wintering areas in the Kiana Hills and southward so that coastal villages and those on the lower Kobuk (Kiana and Noorvik) saw and harvested large numbers of caribou while the upper Kobuk villages of Shungnak and Kobuk experienced poor harvests (Davis, Grauvogel and Reynolds, 1976). Two small herds, totalling an estimated 1,000 animals, were located west of Ambler on March 13-14, when Melchior was conducting surveys in the Kobuk Valley. One group, of about 350-500 animals, was moving to and feeding in an area of tussock tundra located about 40 km west-northwest of Ambler (between the Hunt and Kaligurichearк Rivers) and the other group of about equal size was located south of the Kobuk River but north of the Great Kobuk Sand Dunes. Residents of Ambler said caribou had been in the valley west of Ambler most of the winter and that they were in excellent condition with "lots of fat along the back."

The salient features that emerge from the preceding historical review of caribou in northwestern Alaska, especially in the Kobuk River area, can be summarized as follows:

(1) The written record indicates that caribou were "abundant" in western Alaska in the mid-19th century but started to decline, first in southern coastal areas, then northward and finally inland, leading to very low populations in western Alaska, including the Kobuk River drainage, by the turn of the century. Caribou remained scarse until the mid-1920's, then began to increase steadily finally reaching a peak of about 300,000 in northwestern Alaska by 1964 (Skoog, 1968). Numbers remained high through 1970 (242,000 minimum); then declined sharply to an estimated 52,000 in 1976. Given continuing predation on the herd and its limited internal capacity to add members through reproduction, the low point in the decline may not have been reached yet.

(2) Throughout recorded history, the movements and distribution of caribou in northwestern Alaska have been highly variable and unpredictable regardless of (and perhaps even largely independent of) population size. With respect to the Kobuk River drainage, and more narrowly the area of the proposed KVNM in some years caribou have been totally absent (e.g., when caribou were rare everywhere or because, they did not move that far south during any time of the year even when abundant), very conspicuous within the area (e.g., when they moved into the valley and at least some wintered there), or transient (e.g., passed through the area on their way to wintering range south of the Kobuk Valley). In years when they passed through the Kobuk Valley either on their fall migration to wintering areas, or on their spring migration to calving grounds, or both, they sometimes moved along the coast, sometimes moved along inland routes crossing portions of the upper river only, or sometimes crossed the valley in a broad front that utilized many routes.

(3) Based upon (1) and (2) above, it seems safe to conclude that dependence upon caribou as a major resource by human and non-human predators alike would lead to a precarious existence for the predator since areas of aggregation and routes of travel used by caribou from one year to the next and the number of animals that use particular areas or routes are extremely variable and unpredictable. Some authors have assumed that mobile predators could simply follow the prey (caribou) as a strategy to maintain contact with them but Burch (1972) has convincingly argued against this with respect to humans.

The cause(s) of the rapid decline in numbers of the Western Arctic Caribou Herd are not known but the existing evidence seems to indicate that mortality factors have been more significant than reduced natality. Natality, measured by calf:cow ratios following parturition, has remained approximately the same through both the increase and decline phases of the population (Table 11). Furthermore, limited appraisal of the condition of the range and quality of the animals has not shown evidence of a decline in food availability or quality since 1970. But a major wintering area for this herd, the region south of the Kobuk River, has experienced fires during the 1970-1974 period (Melchior, PART I, this report; Fig. 6) which have undoubtedly destroyed some lichen forage. It is not known if this has any bearing on the population decline but it could. In addition, the herd was afflicted with disease (mainly brucellosis) and animals were

Table 11. Calf:cow ratios and percent of animals tested with positive brucellosis titers, Western Arctic Caribou Herd.

Year	June Calf:cow Ratio	Brucellosis in Herd (%)	Sources
1960	73:100	-	Lent, 1966
1961	42:100	14	Skoog, 1963
1962	53:100	30	Skoog, 1963; Neiland, 1972
1963	-	-	-
1964	64:100	20.2	Lentfer, 1965; Neiland, 1966
1965	-	8.4	Neiland, 1966
1966	-	8.0	Neiland, 1967
1967	-	-	-
1968	41:100	-	Hemming & Glenn, 1969
1969	-	13.0	Neiland, 1970
1970	48:100	-	Pegau & Hemming, 1972
1971	-	10	Neiland, 1972
1972	-	-	-
1973	-	-	-
1974	-	-	-
1975	48:100	-	Davis, Grauvogel & Reynolds, 1976
1976	54:100	-	Anonymous, 1976

in poor condition in the early 1960's (Lentfer, 1965; Neiland, 1966, 1967, 1970, 1972) but the percentage of the herd afflicted with these conditions seemed to be declining while the herd was still increasing (or had stabilized) in size (Table 11). Thus, it is unclear what, if any, affect these conditions had on the long-term viability of the herd.

Three mortality factors, calf overwinter mortality, human harvest and nonhuman predator harvest, appear to be the major factors to which herd losses can be attributed. Calf overwinter mortality has not been assessed each year, but herd composition counts made in 1970 and again in October, 1975 indicate that the percentage of yearlings in the herd has decreased from 15 to 7. If this percentage has been dropping or consistently low since 1970, then it would indicate that survival of calves to one year old was poor. Although no accurate data are available, annual estimates of hunter harvest, based upon a variety of sources, were made during 1963 through 1968 and ranged from a low of 20,000 in 1963 to a high of 29,000 in 1965; since then, estimates of "normal", "above normal" or "below normal" have been made assuming the mean of the six previous years (25,000) equaled normal (Davis, Grauvogel and Reynolds, 1976). In addition to the human harvest, there has been an unknown harvest by nonhuman predators, primarily wolves, which are assumed to have been on the increase since about 1963 when predator control activities in northwestern Alaska were reduced and then essentially terminated by about 1971. In combination, these three sources of mortality, overwinter losses of calves, a high sustained harvest by humans and a substantial but unknown harvest by nonhuman predators, could on theoretical grounds, account for the decline of the population. Other contributary factors, many of which have not been evaluated adequately could have been operating during the decline. The future of the herd is uncertain at this time. A drastic reduction in human harvest has been recommended as a measure aimed at slowing the decline in herd numbers (Davis, Grauvogel and Reynolds, 1976).

The proposed KVNM represents in area about two percent of the range of the Western Arctic Caribou Herd (Hemming, 1971), consequently the contribution that this area makes toward the welfare of the herd is relatively small. This is especially true because the area has not served as one of the more critical portions (calving ground or major wintering area) of the range of this herd throughout historical times. Nevertheless, the rivers within the proposed KVNM draining the Baird Mountains have frequently served as important corridors for the movement of large numbers of animals between the calving grounds and major wintering areas, but similar drainages outside the boundaries of the proposed KVNM have been of at least equal importance in this regard.

Dall Sheep

Reports of early travelers through the Kobuk region indicate that sheep were not common in the Baird Mountains at the end of the nineteenth century or during the early twentieth century. Mendenhall (1902) travelled

the length of the Kobuk River in 1900 and reported only a few sheep near the headwaters. Smith and Mertie (1930) made extensive journeys through the Brooks Range and mentioned that sheep were uncommon in the Baird Mountains, but that they were often the only game animal that could be encountered regularly in the mountainous regions to the east, as far as the Canadian border. Near the headwaters of the Noatak River (Ipmiliuk River) sheep were abundant, and Kobuk Valley natives travelled there to hunt sheep. Based upon a wildlife survey made in the summer of 1949, Scott (1949) reported that:

> "In the Baird Mountains, between the Kobuk and Noatak Rivers, the sheep are in small numbers and almost entirely in the Noatak watershed. The center of abundance seems to be in the highest mountains south of the Noatak canyon (west of the proposed KVNM), although sheep are occasionally seen in the Igichuk Hills near the mouth of the Noatak. Flights over the eastern Baird Mountains failed to discover any sheep or any definite sign of their presence other than as stragglers. Sheep are apparently not present in the Kobuk drainage of the Schwatka Mountains."

More recently, Dean and Chesemore (1974) noted that sheep have a rather erratic distribution in the Baird Mountains. They reported seeing sheep trails at the head of the Eli River, on the Noatak side of the divide and northwest of the KVNM proposal area. They also reported that J. Chesemore and J. Cross saw 7 to 8 sheep on a mountain one drainage east of the Salmon River (Tututsuk River) on July 7, 1963. Cross, a veteran bush pilot, stated that sheep were rare in the Baird Mountains east of the Salmon River. Lorenz Schuerch of Kiana saw large bands of sheep at the head of the Salmon River and on Sheep Creek, a tributary of the Upper Salmon, when he was mining there in about 1950 (pers. comm.).

Irv Tailleur of the USGS and Gar Pessel of Alaska State Geological and Geophysical Survey mapped geologic formations of the Baird Mountains area during 1974. They flew over the area extensively in both a fixed wing plane and a helicopter, and members of their research team walked virtually every ridge system from the Kallarichuk River to the Akillik River. Thus, they covered nearly all of the possible sheep habitat within the proposed area. Although they saw some fresh sheep sign, they saw no sheep. The previous summer, when they were mapping within the Ambler quadrangle just east of the proposal area, they commonly encountered sheep.

On July 25, 1974 we saw 5 ewes and 5 lambs on a ridge top between Sheep Creek and the westernmost fork of the Tututsuk River. There were a few old beds and some lightly worn trails in the vicinity, but there was not enough sign to indicate that large numbers of sheep used that area. Along Upper Sheep Creek, we found fresh sheep tracks, but we saw no more sheep from the ground. There were some signs (beds and trails) of sheep on Anaktok Creek, across the Salmon River from Sheep Creek, and we found

sheep hair in wolf scats there. On August 20, 1974, Ken Whitten and Dick Shideler flew an aerial survey for sheep covering all of the alpine terrain from Salmon River to Hunt River. The only sheep seen were 4 ewes and 4 lambs on the upper east fork of the Tututsuk River. The pilot, Dan Denslow of Ambler, mentioned that he had occasionally seen sheep between the Hunt and Akillik Rivers.

We find no evidence in the literature that sheep were ever very abundant in the Baird Mountains. At the present time, they are certainly not numerous. They occur at very low density and probably in widely scattered groups. Habitat conditions over much of the area appear to be marginal. Along the major tributaries of the Kobuk which flow south of the Baird Mountains, ridges are often very steep, but they are not particularly high. Shrubby vegetation extends to the base of summit cliffs, and alpine meadow habitats are lacking. Near the heads of these rivers, the valleys widen and peaks are somewhat higher. Consequently there is more development of alpine meadows. It was in this region that we saw all sheep and sheep sign during our investigations. In the portion of the Baird Mountains covered by the proposal area, the Noatak Valley is much higher than the Kobuk Valley, and a high rolling plateau extends nearly all the way to the divide. Summits north of the divide are rounded and barren, and although there is sufficient alpine meadow habitat, it is usually isolated from suitable escape terrain. East of the KVNM proposal area the mountains are higher and provide more diverse alpine habitats. There are also well developed spur ridge systems leading toward the Noatak River. This combination seems to support a large and healthy sheep population. To a slightly lesser extent, the same conditions seem to apply west of the study area, also. It appears that relatively low summits and lack of mountain development north of the divide provide only marginal sheep habitat, accounting for both historical and present low densities of sheep in the central Baird Mountains.

Hunting does not appear to be a mortality factor in Dall Sheep in the Baird Mountains. Native subsistence hunters apparently travelled to the upper Noatak to hunt sheep (Smith and Mertie, 1930) probably because such hunting could only be successful where sheep densities were high. Although many Ambler residents have formerly used the Hunt River as an access route to the Noatak Valley for spring caribou hunts, they claim they never hunted sheep enroute. The few Ambler residents who have hunted sheep recently have apparently not done so within the proposal area. For the most part, they have flown to the Noatak to hunt sheep. There is almost surely no sport hunting use of sheep within the proposal area. Sport hunters chartering out of Kiana, Ambler, Shungak, or Kobuk generally fly to the Noatak where there are more sheep and better landing sites.

While poor habitat is probably the main factor causing low sheep population levels, wolf predation may be a contributing factor. Wolf control was extensive during the 1940's and 1950's and the sheep population may have increased somewhat in response. Caribou have used the Baird Mountains and Kobuk Valley extensively only since about 1950 in

recent years, and they may have contributed to increased wolf numbers. This, along with the cessation of wolf control in the 1960's, could have produced more wolves and consequently increased predation on sheep. Disease, exceptional snowfall, and overuse of range may also cause declines in sheep numbers. Conversely, a series of mild winters can lead to population increase. Since the above factors all vary from year to year, fluctuations in sheep populations are commonplace. Habitat is still the overwhelming factor determining population size, and since habitat conditions are poor in the Baird Mountains, the population probably always fluctuates within a low density range.

Habitat Utilization

Animal Trails and Sign

Trails made and maintained by animals were conspicuous in several areas of the proposed KVNM. Red squirrel trails leading from one spruce tree to another and large cone caches were seen in dense stands of white spruce, even in relatively small patches surrounded by non-forested habitat such as the prominent stand located by Ahnewetut Creek where it passes through the Great Kobuk Sand Dunes. Trails were conspicuous in spruce/lichen woodland also. Well-worn trails and large cone caches suggest that red squirrels have been long time residents of these areas. Furthermore, since these squirrels feed extensively, almost exclusively, on spruce seed, especially white spruce seed (Brink and Dean, 1966), these signs of fairly permanent occupancy may indicate that either spruce seed production is a reliable food source or that other food sources are utilized. In interior Alaska, white spruce produce excellent seed crops only every 10 to 12 years, but good crops occur between excellent years (Zasada, 1972). However, in some years, there is very low to no seed production and in such years squirrels must relie on stores from previous years or alternate food sources (Smith, 1968). Since spruce is at the northern limit of its range in the Kobuk, widespread evidence of resident, long-term occupancy by red squirrels suggesting that spruce in the area is a reliable food source, was surprising.

Big game trails were seen in the mountains and in valley bottoms. In the headwaters of Sheep Creek, a tributary of the Salmon River, many, roughly parallel, well-worn trails were present on the nearly barren slopes of the mountains. Droppings and tracks indicated these were probably maintained by both caribou, when migrating through the area, and Dall sheep. Since sheep are not and have not been abundant in this area for the past 75 to 100 years but caribou have passed through in large numbers, caribou are probably responsible for most of these trails. Similar trails, incised in the tundra covering the ground in the headwaters of the Kallarichuk River, were conspicuous to us from the air. These too are probably due to caribou migration. In the high, nearly barren country, the passage of many animals contributes to the downslope movement of loose

surface material and in more moist areas, trails cutting through the vegetative mat clothing slopes, provides a channel for surface runoff water thereby contributing to the erosion of these areas.

Trails attributable to migrating caribou were also seen on the north-facing slopes of the Waring Mountains. These trails passed through forest, then shrub and on up onto the alpine tundra.

Big game trails crossed alluvial terraces along the Salmon River, passing through forest and shrub habitats. Droppings, tracks, and signs of feeding (browsing, torn up Hedysarum patches, etc.) showed that these trails were being used by caribou, moose, bear and wolves. These trails ease passage through shrubs for humans and no doubt serve the same function for big game animals. They may also have intra- and inter-specific social functions as well.

At two locations in the Salmon River drainage and one by Ahnewetut Creek, where it passes through the Great Kobuk Sand Dunes, we found footprint bear trails. These trails consist of a series of pits in zigzag fashion made by bears stepping repeatedly in the same footprints (Murie, 1954; Fig. 10d). One trail passed through a grove of white spruce adjacent to Sheep Creek. A bear rubbing tree was next to the trail. The second trail was very short, only half dozen or so pits, leading up to a rock outcrop on a knob overlooking the upper Salmon River Valley. The third trail, also short, led out of a small spruce stand to the edge of a steep, eroding embankment of Ahnetwetut Creek. At the time of our observation, the trail ended abruptly at a vertical face indicating it was an old trail no longer in use.

Summer Range

No quantitative studies of range conditions within the proposed KVNM have been made but we made limited qualitative assessments as time and travel permitted.

Summer range for caribou is not abundant within the proposed KVNM but small groups of animals have been observed in the Baird Mountains during a portion of the summer in some years (Lent, 1966).

Frequent aerial surveys of a study area on the Tanana Flats, in Interior Alaska, revealed that moose there used aquatic (40%) and low shrub (about 54%) habitats during June and July (Coady, 1974). The moose of Isle Royale make heavy use of aquatic plants during the summer and Jordan et al (1973) suggested this preference may be brought about by a need for sodium, which is low in terrestrial vegetation, but high in submerged, floating and emergent aquatic plants. We observed moose in and near ponds and sloughs during the summer but there are no data available on the proportion of the population or the time spent in aquatic habitats by moose

within the Kobuk Valley. Generally, food is very abundant during the summer; we saw few signs of moose having fed on plants in summer.

The proposed KVNM lacks good sheep range. It is doubtful if the sparsely distributed alpine meadows could support more than the few sheep we found in the Baird Mountains.

Winter Range

Lichens are the principal winter forage of caribou. Although low in protein, fat, calcium, and phosphorus they are high in carboyhdrate and, apparently, digestibility (for caribou at least) thus providing large quantities of energy so vital for maintenance during the cold winters (Pegau, 1973).

Three habitat types within the proposed KVNM, lichen woodland, tussock tundra, and Dryas lichen dwarf scrub (Racine, PART II, this report), are important lichen areas. Together, lichen woodland and tussock tundra represent about 10% of the area (ibid). The scrub type forms a mosiac with several other types and could not be separated from the other types given the scale of habitat/vegetation mapping, consequently, there is no estimate of its extent.

As pointed out in our historical review of caribou populations, the Noatak, Kobuk and Selawik River basins have been used as wintering areas since at least the 1950's. Although not utilized every winter, the middle Kobuk Valley has been utilized by at least small groups of animals quite often during the past 25 years and frequently, caribou pass through the area on their migrations to and from the calving grounds to the north. Thus, it was surprising to find that the lichen woodland areas we examined showed so little sign of having been grazed. During Melchior's visit to one of these sites in March, 1975 he found 90 cm of soft snow covering the ground (Melchior, PART I, this report), an amount sufficient to make it energetically inefficient for caribou to utilize. Since the 1974-1975 winter had a below average snowfall (ibid, Table 6), it is probable that snow on the ground could be much deeper at this site (and other similar sites) during some winters, and even in winters of lighter snowfall, there may be too much snow for caribou to efficiently utilize the lichens in this habitat type. Also, if snow cover was thin in this habitat, it would probably be thinner still in other areas with good lichen growth thereby making them a more attractive source than the lichen woodland site. Henshaw (1968) reported that caribou wintering in the Kobuk region did not dig feeding craters in snow deeper than 70 cm and only rarely did they dig in more than 50 cm of snow. In the tussock tundra habitat where caribou were seen feeding on March 14, 1975, snow depth ranged from 39 to 50 cm (Melchior, PART I, Table 7, this report).

Clearly, summer assessment of winter range reveals where suitable lichen growth occurs but winter assessment is necessary in order to determine how

much of the lichen is actually accessible. Furthermore, because of seasonal and year to year variation in snow depth and hardness (Melchior, PART I, this report), it is necessary to examine sites over a period of several years if one wishes to evaluate the quality of an area as winter range for caribou.

Food consumption by moose is less in winter than in summer (Gasaway and Coady, 1974). This reduction in intake is accompanied by a shift from less woody forage in summer to woody forage in winter. Willow, birch, aspen and poplar are utilized. Usually the young shoots of the previous summer are eaten; old stems and stems of decadent shrubs are not used. Although shrub habitats provide most of the winter forage for moose, forest and woodland habitats are utilized for cover. During our survey of the Kobuk River in March, 1975 moose were concentrated along the river but were found in both willow shrub and spruce forest habitats.

The proposed KVNM contains several types of shrub habitat (Racine, PART II, this report). About 5% of the area is in low or high shrub habitat containing shrubs that could serve as winter forage; an additional 17% contains shrubs (mainly alder at higher elevations) of doubtful value to wintering moose.

Snow depth, density and hardness affect habitat utilization by moose in winter (Coady, 1974). Depth and hardness are most important since they represent the thickness through which an animal must move if not supported by the snow, and the force that must be exerted to move through the snow as well as the capacity of the snow to support an animal (ibid). As the winter progresses, snow tends to cover low shrubs, thus making them inaccessible as forage and to inhibit access to tall shrubs which protrude above the snow.

In March, 1975 snow depth and hardness were measured within three willow shrub habitats in which moose had been browsing (Melchior, PART I, Table 7, this report). Although the snow was relatively soft at all three sites, the depth of snow which ranged generally from 71 to 90 cm, was in the range that definitely impedes the movement of moose and is only slightly below the critical depth of 90 to 100 cm (Coady, 1974). Depths greater than this can so restrict movement that moose might be unable to acquire adequate quantities of food (ibid). Since the snowfall during the winter of 1974-1975 was below average (Melchior, PART I, Table 6, this report), these same sites might be unusable in years of greater snowfall. As pointed out in the case of evaluating caribou winter habitat, evaluations of moose winter habitat must include examination of snow characteristics in relation to areas containing suitable browse. Since no adequate winter survey has been done within the Kobuk drainage a meaningful evaluation of the quality of winter ranges can not be made at this time.

DISCUSSION AND CONCLUSIONS

Throughout sections of this paper, a number of points have been discussed within the context of the material being presented and reviewed. The discussion here looks at broader issues. Four topics are considered: population fluctuations, habitat in relation to fire, the size and shape of the proposed KVNM, and human beings as biological components of the system.

From the data presented and reviewed, it is abundantly clear that each species for which sufficient historical information exists, undergoes pronounced fluctuations in numbers. That populations in the proposed KVNM resemble northern animal species elsewhere in this regard comes as no surprise to ecologists and other students of northern or cold-dominated ecosystems.

It is beyond the scope of this discussion to examine all the theories that have been espoused to explain the pronounced fluctuations that have been observed in northern animal populations; others have already reviewed many of them (e.g., Dunbar, 1968; Keith, 1963). There are several factors, however, that must be taken into consideration when developing any explanation of the fluctuations. These include: (1) recognition of the fact that northern ecosystems have had a relatively short time to develop since areas were last covered by glaciers, especially mountainous areas, (2) high latitudes receive less solar energy than lower latitudes, thus limiting productive capacity, (3) summers are short, winters long, and (4) physical environmental conditions are highly variable and marked by extremes that exhibit no obvious, predictable patterns. All of these conditions are likely to lead to low species diversity and simple food chains in contrast to temperate and tropical regions where greater species diversity and more complex food webs in terrestrial systems are generally, but not always, the rule. The Kobuk region, is subject to the conditions enumerated above and therefore exhibits low animal species diversity in common with other northern areas. Furthermore, Melchior (PART I, this report) has shown that the Kobuk region experiences pronounced fluctuations and extremes of physical environment. Such extremes can have catastrophic effects on populations, and can lead to pronounced fluctuations in numbers. Even if numbers are not diminished in the absolute sense by climatic extremes, such conditions can induce major shifts in the use of space by very mobile species, such as caribou responding to extreme snow conditions. With respect to a given location, the overall effect is the same, that is, pronounced fluctuations in animal abundance.

Changes in habitat, a factor not enumerated above, can also contribute to fluctuations in populations. Habitat changes due to long-term climatic fluctuations did occur within the Kobuk Valley during the late Quaternary (Melchior, PART I and Racine, PART II, this report) but evidence of short-term changes in habitats due to changing climate have not been reported. However, during recent years, fire has affected an estimated 18% of the valley floor within the proposed KVNM (Melchior, PART I, this report) as

well as many areas outside the proposed monument, especially to the south (ibid, Fig. 6). As Cowan (1951) and Leopold and Darling (1953) have pointed out, habitat disturbances such as fire, tend to favor those species that utilize successional stages (e.g., moose) at the expense of those species that utilize climax, or if you prefer, less rapidly changing or undisturbed habitats (e.g., caribou). Although moose and beaver, another species associated with successional habitats, have been on the increase and caribou on the decrease in the Kobuk region, fires have not been so extensive as to cause us to think that fire is the only, or even the major factor affecting these population changes. However, the changes in habitat brought about by fire could be a contributing factor along with other factors. Moose, for example, make heavy use of glacial, riparian and fire-created seral communities throughout the state (LeReshe _et al_., 1974) and the latter have supported the greatest population explosions and greatest densities of moose in the state (Bishop and Rausch, 1974; LeResche _et al_., 1974).

In several respects, the size of the proposed KVNM is rather small relative to the ebb and flow of major populations. Important commercial and subsistence anadromous fish pass through the monument area, some spawning in tributaries within the proposed monument, but most of the fish seem to utilize tributaries that lie outside the boundaries for spawning. Similarly, caribou pass through the monument area on their migrations between calving and wintering grounds but not in every year. Only a small proportion of the northwestern Arctic herd has wintered within the monument boundaries over the past 30 years and again, not every winter. Other big game species, such as black and brown bear, wolves and moose, require such large areas for maintenance at northern latitudes that the total area of the proposed KVNM (7,500 km^2), a sizeable area by lower 48 standards, supports only a relatively few individuals of each of these species. Given the large fluctuations that the fish and big game populations have shown throughout the historical period of record, protection of both aquatic and terrestrial habitats over a much larger area than is encompassed by the boundaries of the proposed KVNM will be necessary to ensure continuing biological viability of these populations in northwestern Alaska.

People have lived within the Kobuk River drainage for thousands of years and reside there today. They have in the past and continue today to make extensive use of the renewable resources not only within the Kobuk drainage but in adjacent drainages as well. A recent study[3] reviews past uses and documents current uses of these resources.

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[3]Anderson, D. D., R. Bane, R. N. Nelson, W. W. Anderson and N. Sheldon. 1976. Kuuvangmiit, Traditional subsistence living in the latter 20th Century. Dept. Interior, Nat'l Park Service. Unedited, pre-publication draft. 556 pp.

Biologically, humans engaged in a hunting-gathering economy occupy the role of top predator and carnivore within the ecosystem. Although plant resources such as berries, leaves and roots are gathered for food, the primary component of the diet is meat. Since, as we have shown, the major fish and mammal populations of the region undergo large fluctuations in numbers both in space and time, the top predator in such a system must, to be successful, have two important attributes: (1) the predator must be opportunistic so that when one species is not abundant or readily available it can turn to alternate prey, and (2) the predator must have mobility to enable it to seek out its prey when and where it exists. In addition to these two attributes of the predator, the ecosystem dictates that the predator population remain low relative to the size of the prey populations and further, that the predator population maintain a low density relative to its search area (or area of utilization). These constraints exist because of the very nature of terrestrial ecosystems in general (food and energy pyramids) and cold-dominated ecosystems in particular. Several of the reasons for this were mentioned earlier in connection with our discussion of population fluctuations. These fluctuations, which bring about periods of boom and bust in the availability of the renewable resources of cold-dominated ecosystems, impose the constraints of small population size and low density upon the top predator or user of the resources.

Recognition of these relationships leads to the conclusion that (1) from a biological-ecosystem point of view, the proposed KVNM represents a very small portion of a large, natural ecosystem in northwestern Alaska that has been functioning for the past several thousand years, and (2) the piecemealing of this area by ANCSA into relatively small land units, which results in a proliferation of owners with different management goals and policies, is generally incompatible with the continued existence of this large ecosystem and the renewable resources it provides for the hunting-gathering economy.

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